1991 SCIENCE & TECHNOLOGY POSTURE HEARING WITH THE DIRECTOR OF THE OFFICE OF SCIENCE AND TECHNOLOGY POLICY

HEARING

BEFORE THE

COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY U.S. HOUSE OF REPRESENTATIVES

ONE HUNDRED SECOND CONGRESS

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1991 SCIENCE & TECHNOLOGY POSTURE HEARING WITH THE DIRECTOR OF THE OFFICE OF SCIENCE & TECHNOLOGY POLICY

WEDNESDAY, FEBRUARY 20, 1991

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY,
Washington, D.C.

The committee met, pursuant to call, at 1:35 p.m., in room 2318, Rayburn House Office Building, Hon. George E. Brown, Jr. [chairman of the committee] presiding.

The CHAIRMAN. The committee will come to order.

The chair has a relatively brief opening statement, and then we will recognize the ranking Republican for an opening statement and any other Members who may have brief opening statements. We are going to try and keep a certain amount of control over the amount of time spent on opening statements, in accordance with the committee rules that we adopted recently, for our guidance only, of course.

Today, our committee conducts the eighth in a series of annual R&D Posture Hearings with the director of the Office of Science and Technology Policy in the White House. This Posture Hearing serves a number of important purposes. It provides the executive branch the opportunity to present an overview of the many diverse science and technology activities of the Federal Government; it affords the senior science policy officer of the administration the opportunity to elucidate the objectives and policies undergirding the President's budget proposals for research and development.

For this committee, our R&D Posture Hearing serves as the starting point for our review of the new budget proposals. Each of our subcommittees will focus on one or more components of the budget and this hearing will help all of us to understand how these components go together and what the overall policy rationale is.

A closely related purpose of this hearing has been to have the OSTP director present to the Congress the major science policy report due on January 15 each year, alternately the Science Indicators Report and the Science and Technology Report and Outlook. Regrettably, this year's report has been delayed, and we hope that we can take that up at a later time.

Personally, I am encouraged by much of what is in the budget proposals. The strong support for the space program will, I am confident, have the support of this committee. The commitment to the doubling of the budget for NSF is among our highest priorities. In other areas, the Congress will want to examine closely the prior-

ities reflected in the budget. The energy R&D program has a very strong basic research component. The generic technology component for energy technologies must undoubtedly be considerably augmented. And environmental R&D must be strengthened across the board so that the major global problems can be both studied and action taken.

In his remarks two weeks ago to the Economic Club of New York, President Bush noted that the Government must help translate the results of basic research into the generic technologies that strengthen our industries and improve our lives. That represents a significant recognition by the administration that the Federal Government has an important role in this field. I look forward to hearing from Dr. Bromley what specific initiatives will be taken in this and coming years to carry out this generic technology policy.

And, finally, I must note that, in spite of the substantial increases in Government support for research in recent years, there is considerable concern in the university research community about the growing disparity between the number of scientists applying for Federal support and the number of dollars available to support that research. I am sure Dr. Bromley, having attended the AAAS meeting just recently, is well aware of this.

This growing disparity, coupled with the steady growth in the cost of research, is creating what Dr. Bromley earlier this month called a series of inevitable outyear mortgages. In my view, we will be well advised to begin now to consider how that long-term question must be dealt with if our university research community is not to see further disappointments.

Now I want to personally welcome the director of the Office of Science and Technology Policy, Dr. D. Allan Bromley. He is a distinguished scientist in his own right. Over the years, he has also made many fine contributions to the science policy deliberations in this country. I look forward to his statement and to our discussion.

I have already told him that I have read his prepared statement, the full text, and I consider it to be probably the best that I have seen in the years that I have served on this committee, and we hope that he will be able to continue in that fine tenor.

And now I will recognize Mr. Sensenbrenner for a few remarks.

Mr. SENSENBRENNER. Thank you very much, Mr. Chairman.

First of all, let me welcome you, Dr. Bromley. You come bearing good news, because there is an increase in most functional areas of the science budget, so you are not being a Cassandra, coming here defending something that we do not want to hear.

Secondly, Mr. Walker is not here; he does have an opening statement; and I would like to ask unanimous consent that his opening statement be placed in the record at this point.

The CHAIRMAN. Without objection, it will be done.

[The prepared statement of Mr. Walker follows:]

OPENING STATEMENT OF THE HONORABLE ROBERT S. WALKER
FY 1992 RESEARCH AND DEVELOPMENT POSTURE HEARING
FEBRUARY 20, 1991

Dr. Bromley, you come before the Committee today with the enviable task of presenting a research budget which shows increases in virtually all areas. I am pleased that the Administration is demonstrating such a strong commitment to science and technology by presenting us with a budget request for a 13 percent increase in R&D.

The money spent on research and development today truly represents our investment in the future; for the economy of the next quarter century and the jobs that will be created depend on our ability to develop a solid technology base today.

I was encouraged to see that the President went beyond the now usual method of attacking a challenge merely by increasing federal spending. In advocating changes to the tax code to boost private investment in the nation's research and development infrastructure, he rightly recognizes that the federal sector has partners in this effort. Although the federal government has an important role in providing funding for basic research, we should also be encouraging the private sector to engage in research activities.

As the authorization process gets underway in the next month, we will be taking a closer look at the specific programs proposed in the budget, but I am confident that we can follow through on this effort to ensure that this nation has a strong science program.

The CHAIRMAN. Does the distinguished vice chairman have any opening remarks that he would like to make?

Mr. SCHEUER. Thank you, Mr. Chairman. I do not, but I hope later on to ask Dr. Bromley, whom we all respect and admire, how he can explain what seems to be the anti-science posture of the President's announced energy program, wherein he virtually ignores the potential of high technology that is already on the shelf, that promises an enormously advantageous cost/benefit pay-off to society in terms of energy savings and energy efficiency, at a time when apparently this black viscous substance known as oil is important enough to encourage us to send half a million Americans out there, risking their lives, and perhaps in the next few days to become engaged in a ground war, but is not important enough to induce us to harness science and technology to the mission of reducing our dependence on Persian Gulf oil. And I will be happy to ask him in more detail later on, Mr. Chairman.

The CHAIRMAN. He will have ample opportunity to respond in more detail, Mr. Scheuer.

Mr. Smith, you asked for recognition for an opening statement.

Mr. SMITH. Thank you, Mr. Chairman.

Mr. Chairman, I would like to offer a personal and especially warm welcome to Dr. Bromley this morning on the strength of Dr. Bromley's teaching me freshman physics when I was in college. I ought to also confess that I went to college expecting to be a physics major, and I won't say how tough the course was, but I will say that I was disabused of that notion very quickly. Nevertheless, I enjoyed my tutorship under Dr. Bromley very much.

Mr. Chairman, the President has submitted an ambitious and balanced research and development budget, and I hope that Congress will implement its many provisions. As the National Energy Strategy is made public today, I cannot overemphasize the importance of oil and gas research to America's future. The first priority must be placed on keeping our domestic oil and gas fields open and producing. A vigorous, enhanced oil recovery program plays a critical role in ensuring continued domestic production.

Biotechnology contributes greatly to America's competitiveness. Research grant funding through the National Institutes of Health plays a key role in attracting students to health science careers. Also, the supercollider will keep the United States at the forefront of physics research. In the past, basic investments in the research of the atom have been repaid many times over in terms of new technology, new jobs, and advances in medicine.

Implementing this research and development budget will determine America's place in the world order of science, space, and technology in this decade and beyond.

Mr. Chairman, let me also say that I have a conflict at 2 o'clock and will not be able to stay for the entire length of Dr. Bromley's testimony, but I know that my colleagues will find it most informative.

Thank you, Mr. Chairman.

The CHAIRMAN. Mr. Ritter.

Mr. RITTER. Thank you, Mr. Chairman, and I would like to welcome you, Dr. Bromley, and to commend you for your success in moving the issues of science and technology to a higher plane of

discussion within the administration in your term as science advisor to the President.

The President's budget contains a healthy increase in R&D funding and supports major R&D programs. The increases in R&D funding seed initiatives, such as the expanded Global Climate Research Program and the High-Performance Computing Initiative, and I support those.

But it seems that an evaluation and an ordering of our priorities for the Federal R&D economy as a whole is barely beginning. I do not see how we can continue to ask for hundreds of millions of dollars of new funding annually for major projects and double-digit percentage increases in R&D at Federal agencies and expect a credible response from those committees and others who control the checkbook.

I believe we must promote Federal R&D policies which place high priority on U.S. industrial competitiveness. We seem to downplay the view of the private sector in spending the billions of dollars that we pour into R&D every year. Why should we be so wary of R&D which can lead to success in the global marketplace?

We have been successful in basic research and the development of technology, too, but we won't be players in the global competitive economy of the decade of the nineties and the next millenium if we do not take our technology and apply it in the marketplace and apply it faster and at higher quality. But that implies a whole range of other imperatives where, again, we are not exactly world leaders.

Dr. Bromley, you have worked hard to ensure that our Federal R&D spending does more to improve America's industrial competitiveness, and I would like to hear about your ideas and initiatives on that subject. Unfortunately, I, too, have a 2 o'clock meeting, and it is one of those days, Mr. Chairman, but we do look forward to the testimony of Dr. Bromley.

Thank you, Mr. Chairman.

The CHAIRMAN. Thank you very much, Dr. Ritter.

I am going to recognize one or two additional opening statements, but I am trying to discourage them, where possible.

Mr. Roemer.

Mr. ROEMER. Mr. Chairman, I appreciate that.

I have an opening statement that I will just enter for the record in order to expedite this proceeding. But I would just like to say, I will be riveted to my chair when the chairman says this is the best testimony he has seen in his time up here on the Hill, and I am hopeful that it will touch on some of the issues in my statement, whether it be renewable energy sources that we need to look at for the future, whether it be encouraging young research scientists at our universities to be awarded and rewarded in grants, and that we look, in science and math education, for the foundation of our educational structure; I appreciate your hitting on those comments as well. But I am anxious to hear your testimony.

Thank you, Mr. Chairman.

[The prepared statement of Mr. Roemer follows:]

DRAFT

OPENING STATEMENT
of

The Honorable Tim Roemer
Committee on Science, Space, and Technology

1991 R&D Posture Hearing
February 20, 1991

I am delighted to join Chairman Brown and my colleagues in welcoming Dr. Bromley to this important hearing. The nation's investment in science and technology and in science and mathematics education is, in my view, one of the most important we can make.

There are many significant parts to the Federal research and development program, but I will highlight only a few. In the field of energy we have the urgent need for a cohesive energy policy. Many opportunities exist for reducing our reliance on foreign oil. As an example, the wider use of ethanol should be encouraged and the price of ethanol can be further reduced by additional effort in research.

University research is the backbone of the nation's scientific research effort, and grants to individual investigators is the core of that effort. I am concerned about the increasing difficulty being experienced by university scientists, especially the younger investigators, in obtaining grant support from the Federal science agencies.

Central to the health of the national economy, including our entire research and development effort, is a sound educational structure. Education at all levels in the fields of science and mathematics is important for several reasons. It is clearly important to insure that we can meet the future needs for engineers and scientists; but it is equally important, I would emphasize, to insure that our future labor force and our citizenry as a whole has the sound educational grounding which a society based on science and high technology requires.

I look forward to hearing Dr. Bromley's discussion of these and other aspects of the Presidents budget proposals.

The CHAIRMAN. Thank you, Mr. Roemer.

Did you have a statement, Mr. Bruce, that you wanted to make?

Mr. BRUCE. I was discouraged by the Chairman.

The CHAIRMAN. Fine. The chair is happy to hear that.

May I indicate to all of those Members who may not be able to remain for the full hearing—may I encourage you to read Dr. Bromley's full statement, which he will probably abbreviate as he goes through, but it will give you a perspective on the work of this committee that I think will be of immense value to you.

Also, the chair will, as he has in the past, try to recognize Members on the basis of the time at which they arrived at the committee, alternating between the two sides, and with that introduction, Dr. Bromley, I think we are ready to hear from you, and, again, we are very pleased to have you here.

[The prepared statements of Mr. Costello, and Mr. Mineta follow:]

OPENING STATEMENT

BY U.S. REP. JERRY F. COSTELLO, ILLINOIS

COMMITTEE ON SCIENCE, SPACE AND TECHNOLOGY

SCIENCE AND TECHNOLOGY POSTURE HEARING

FEBRUARY 20, 1991

Mr. Chairman, today we will hear the views of the Director of the White House Office of Science and Technology Policy, Dr. D. Allan Bromley, on the Federal Research and Development budget for fiscal year 1992.

It is necessary to take a close look at the President's budget and evaluate the priorities set therein. Today I look forward to exploring those priorities and ensuring that our space dollars are effectively used. It is heartening to examine all aspects of the Federal government's science and technology policy.

Mr. Chairman, I want to thank you for holding this hearing.

STATEMENT BY NORMAN Y. MINETA, M.C.
SUBCOMMITTEE ON TECHNOLOGY AND COMPETITIVENESS
COMMITTEE ON SCIENCE, SPACE AND TECHNOLOGY

FEBRUARY 20, 1991

Mr. Chairman, I congratulate you for holding this hearing to focus on the role of the Office of Science and Technology Policy and to review the President's fiscal year 1992 research and development budget proposal.

The rationales for investment in research and development have not changed over the years. The United States has always been willing to put a downpayment on the future by exploring our intellectual frontiers today. What has changed is the need to refocus our limited resources on the competitiveness of our civilian and commercial industry rather than continue an unabated buildup of our military.

My fear today is that the war in the Middle East will result in a renewed emphasis on defense technology to the detriment of our civilian economic future.

Mr. Chairman, despite the gravity of the crisis in the Middle East, we must never lose sight of our long-term national and international interests. For far too long the White House has ignored the connection between our industrial competitiveness and our national security.

I believe we will win the military war in the Persian Gulf. But that military victory will have a hollow meaning if winning on a foreign battlefield means losing ground economically here at home. Once we have accomplished our military objectives, we must put as much effort into winning peace as we do into winning the war.

We need to keep pace with the peace by spending our research dollars on our future. We must develop a research environment that will respond to the critical needs of strategic industries.

The government must invest in the generic technologies that are the building blocks of every industry: semiconductors, x-ray lithography, advanced manufacturing, advanced electronics, superconducting, and advanced ceramics.

While I am pleased that the White House has chosen to support high performance computing, I am disappointed that the budget allocates so little to the other strategic industries. The Advanced Technology Program, for example, deserves much greater attention than it receives in this budget.

I believe that one part of the federal research and development equation is equipped today to support these strategic industries: our national labs. We simply must learn to utilize them.

The staggering cost and risk of commercializing new technologies is one of the reasons the United States is having difficulty competing in the world market. The national labs represent a vital resource that has been unresponsive of the needs of U.S. industry. It is time to reexamine the role of the labs and chart a course for the 1990s that corresponds with the needs of domestic industry.

We need to establish a mechanism that allows American business to take advantage of the expertise and resources available at our national labs.

Mr. Chairman, our national labs have the most advanced research equipment in the world. Our citizens are the most creative and innovative in the world. We need to develop a national strategy that facilitates shared research efforts.

I look forward to hearing Dr. Bromley's elaborate today on the President's R&D budget for fiscal year 1992. I hope he will offer some good advice about how the government can collaborate with American business to ensure a competitive future for our children.

Thank you.

STATEMENT OF DR. D. ALLAN BROMLEY, DIRECTOR, OFFICE OF SCIENCE AND TECHNOLOGY POLICY, EXECUTIVE OFFICE OF THE PRESIDENT, WASHINGTON, DC

Dr. BROMLEY. Thank you, Mr. Chairman.

It is, of course, a great pleasure to be here, to have this opportunity to discuss with you the proposed budget for research and development for fiscal year 1992 and to answer your questions concerning that budget and the science and technology policies of this administration.

What I would like to do, with your permission, Mr. Chairman, is simply abbreviate my formal statement and then respond to the questions. I would ask that the full statement be included in the record.

The CHAIRMAN. Without objection, it will be included.

Dr. BROMLEY. Thank you, sir.

As you noted, Mr. Chairman, research and development and education have been given special attention in this year's budget, and they reflect the President's firm commitment to investing in our national future and his belief that education and research and development represent two of the most effective investments that we can make in that future.

There are a whole series of aspects of this investment—spending on education, preventative health care, research and development. All of these things we expect, sir, to pay back many times over the investment that we make, and I would emphasize that, although I will touch on economic arguments, that these are certainly not the only ones that are important and that national security, environmental quality, intellectual and cultural vitality, and, in fact, spiritual inspiration are all parts of the return that I anticipate that we as a Nation will get from the investment in these areas.

As all of you gentlemen and ladies know, the 1992 budget proposes to spend $75.6 billion for research and development, including research and development facilities, and that is an increase of 13 percent over what the Congress appropriated in fiscal year 1991. Defense-related research and development would rise by 14.5 percent, civilian research and development by 9.5 percent, and funding for basic research by 8 percent, so that I am pleased to present this budget to you, because I believe that it is a good budget, that it, in fact, reflects fairly the emphasis that we wish to place on science and technology. And I believe that it reflects a shared view with you and your colleagues of the importance of the goals that we share in this area.

I will return to the specific budget initiatives in a moment, but I thought that it might be worthwhile to begin, Mr. Chairman, by simply touching on some of the criteria that we give the highest weight to in developing the budget that we bring before you. There are, in fact, in my view, four broad and sometimes overlapping categories that should be considered in putting together this request to you. The first I have already mentioned; that is investing in the future. The second is that of meeting obvious national needs. The third is the adventure, if you will, of the exploration of intellectual and physical frontiers. And the fourth, and by no means least, of these is the role that research and development plays in strength-

ening the educational activities of our Nation in science, in mathematics, in engineering, in providing a trained work force and the professionals that will move us forward in the years ahead.

To turn first to the investment in the future, I think it has long been recognized by all of us that investment in research and development has a high rate of return. Economists have estimated that more than half of the per capita growth in the U.S. economy since the Great Depression has been due to what one might call new knowledge, the result of research. And focusing specifically just on the research that the Federal Government has supported at the Nation's colleges and universities, a very distinguished economist, Edwin Mansfield of the University of Pennsylvania, has reported an average social rate of return on investments over the prior 15-year period of 28 percent, and I think that that is a very important number, because it is the first one that I know of that has been prepared after a detailed study by a very widely recognized and distinguished economist.

Beyond the economic return, of course, science and technology have made massive changes in the quality of our lives. We have, in many cases, what even a few years ago would have seemed like miraculous new cures for some of the scourges that have affected man over the centuries, new vaccines, new treatments; we have greater mobility as a society; we have a much wider range and selection of foods, other products; we have improved accommodations; new forms of recreation, entertainment; and, all in all, I would submit, Mr. Chairman, that our lives have been made more comfortable, more fulfilling, because of the activities that have been carried forward jointly with the Congress over the years. And I would want to state right at the very outset that it is too often forgotten that we have in the United States the strongest science and technology enterprise overall that the world has ever seen, and that, I would submit, is a tribute to the wisdom of groups like yours and the taxpayers who have supported this program very generously over the years since World War II. I believe it has been a good investment, but I think it is only appropriate for me at the outset to recognize that fact.

One of the important things, I think, that we have to keep in mind is that the pay-off from research and development depends very critically on the fields, on matters of chance, and no one can really predict, particularly in basic research, when, where, and to whom the return will come, but if history has taught us anything, it has taught us that that return will come and will come with a high rate of return.

The decision we must make is whether we are prepared to invest in the future of our children and our grandchildren, and if we choose not to grasp the opportunities that science and technology lay before us at the present time, then we, in fact, are resigning ourselves, in my opinion, to a future that is less prosperous and less secure than could otherwise be the case. And I would like, in all of my statements today, to emphasize that, in asking you and your colleagues, Mr. Chairman, for support of this budget, I want to focus not on the fact that there are many people who do not feel that they are getting enough funding for their work, although that is important. What I want to focus on is the fact that there are tre-

mendous opportunities out there that will go unrealized if we do not support some of our very excellent people, and that, I think, is the key question.

Let me turn then to the next item; that is, meeting national needs. The President's budget provides for continuing and, where appropriate, increased support for a broad range of Federal R&D activities that address identified needs. These include areas such as energy, the environment, national defense, advanced technology, and, of course, health, and, as one example, I would turn to the U.S. Global Change Research Program. It is a program that is now familiar to you, because it has now been produced over the past two years by the Committee on Earth and Environmental Science operating under the Federal Coordinating Council for Science, Engineering and Technology, a group that has the perhaps unfortunate acronym, FCCSET.

What the President has requested this year is an increase of 24 percent for this program and, in doing so, has committed the United States to playing a major leadership role in understanding the global system: how does it function? What can we do toward predicting the future so that we can make realistic policies about many aspects of the environment? And this is a program which we have sent forward together with a detailed program plan from the committee, and I recommend that program to you.

It is important to emphasize that, in response to the tremendous international interest and activity in this field, we in the U.S. will have doubled our support of research in this important field since it began as a major program in fiscal year 1990, if you agree with our request.

Another example of a special presidential initiative in this year's budget is that in high performance computing and communication. I cannot think of any other single item that has a greater potential for positive change in our society than this program of making available to a far greater fraction of our citizens some of the truly remarkable power that is now available in the information handling, information treatment, technologies. The progress here has been dramatic in the past few years, and our challenge now is to make that progress available to a much greater fraction of our citizens so that it can play a much more important role in economic competitiveness and in education, to mention two of the areas that I consider most important.

I have been very much impressed by the fact that a single optical fiber going into a classroom can result in every student in that classroom being given individualized instruction, self-paced, with immediate reward when a concept is grasped and repetition when it is not, and this can revolutionize one of our most serious problem areas.

National security is obviously one of the areas of great importance, and I think that all of us, watching what has been happening in Desert Storm, have had it brought home to us in very effective fashion that American technology not only does work but it, indeed, is saving a great many lives of young Americans, of our allies, and, indeed, the lives of many civilian members of our aggressors.

These systems that are now in operation reflect wise decisions that were made 10 and 20 years ago, and it is important for us to recognize that this continued investment is responsible for the advantages that we have quite obviously on our side in Desert Storm today.

The third major criterion that I would submit to you, Mr. Chairman and members of the committee, is that of exploring our frontiers. When the chips are down—and perhaps it is simply because I have been at it for so many years—but I view science and technology as perhaps one of the greatest adventures that mankind has access to. And I think we must never become so practical that we forget the tremendous intellectual and cultural importance of pushing back the frontiers of human ignorance. We are, by nature, a curious and inquisitive lot, and I think it has been the hallmark of great nations through history that they have not faltered or pulled back from exploring the frontiers of their time, and when they did, as in the case that we all know of the Chinese, then of the Portuguese, they fall back from the frontiers and fall back from world leadership rather quickly.

The challenge that I have just mentioned, this adventure, is clearly one of the justifications for our continued exploration into space. Of course, space activities provide much more tangible benefits: new products; new processes; a stronger scientific, technological base; and, perhaps as important as anything else, stimulus to a whole generation of young people, who have become convinced that we, indeed, are still masters of technology, that we can still do things on the very frontiers and that we can do them well.

Over the past year, the U.S. space program has been undergoing what I consider a very healthy and a very intensive review, and, as a result of that review, the program, as you know, is undergoing important changes in direction, important changes in character. This year's budget would commit $2.1 billion, a 21 percent increase, to the scientific component of the space program, and that, of course, is in keeping with the report of the Augustine committee that, in my view, has done an outstanding job in a short time scale of reviewing and making recommendations concerning our future in space.

NASA's proposed $15.7 billion budget includes, in addition to space science, two other very important initiatives. Mission to Planet Earth I consider extremely important, because it allows us to use this new frontier and the new technology we have developed to illuminate a vast number of important problems here on the Earth's surface, and I give this very high priority. I am particularly interested in what we can do with the new earth-observing system which will impact a vast number of sciences and areas quite apart from global change where it is normally discussed.

And, lastly in the space area, I would come back to Mission from Planet Earth. Mission from Planet Earth is our attempt, in an orderly fashion, to plan for the movement of mankind finally out and away from the home planet, and surely is one of the greatest adventures of all. And I believe that, with the help of the Augustine committee, we are now approaching that particular part of the space program in a measured and important new way.

Fourthly, and something that normally does not get included in this list of criteria, but one that I feel is terribly important is this matter of education in science and mathematics, and it is important for so many reasons. It is important, first of all, because if our citizens can not understand at least the broad outlines of the increasingly technological issues that are being brought forward, even though they can not be expected to participate in the resolution of those issues, they are going to become alienated, withdrawn, and we as a society simply can not afford that. That is the first point.

The second point is that we desperately need more trained technical people to operate our increasingly sophisticated production lines. That is a key to economic competitiveness, and it is a key that we have tended to forget. We have not invested, as we should, in our two-year colleges, where a great many of those folk come from.

And, finally, of course, is the production of the trained professionals, the leaders who will move us forward in the frontiers of science, of technology, of manufacturing, and of competitiveness. I used to think that one could consider economic competitiveness and national security as two quite separate issues; I do not any more; there are so many technologies that span both that they really must be considered together.

I think that we have a major challenge ahead of us, and, for that reason, following up on the President's education summit and his subsequent meetings with the governors, we have put together under OSTP's FCCSET, a Committee on Education and Human Resources. It is a very important committee; it is chaired by the Secretary of Energy, James Watkins, and vice-chaired by Ted Sanders, deputy secretary of education, and Luther Williams, the head of the Education Program of the National Science Foundation. But perhaps even more important than that is the fact that every agency in the Federal Government is represented on that committee and is represented with real enthusiasm, because there is a recognition throughout the entire administration that education is probably our most important task and our most important challenge at the moment.

Guided by the education goals of the President and the governors, this committee has, first of all, for the first time, given us and you an inventory of what the Federal Government is actually doing in the field of education in mathematics and science and has gone beyond that to identify at least the beginnings of recommendations that give us the hope of meeting the President's goals, the most ambitious of which, you will recall, is that by the year 2000 American students will be second to none in science and mathematics. Given where we are starting from, that is an ambitious goal. Yet it is one that I believe that, working together, we can meet.

The major area of concern identified by our committee is pre-college, and, in fact, in pre-college it is not in the secondary schools but in the elementary schools. One of the reasons for that is that, as distinct from most other careers, scientists, mathematicians, and engineers tend to make their career decisions by the junior year in high school, and if we have lost them by that time, we have lost them permanently.

We also have identified that the major problem in the pre-college arena and, in particular, in the elementary schools is the fact that so few of the teachers in those schools have the kind of background and credentials and professionalism that we would like to see and that I believe that our children have the right to expect.

In fiscal year 1991, the Federal Government spent $1.7 billion expressly for science, mathematics, and engineering education, and in 1992 the President has proposed a 13 percent increase, to about $1.94 billion. But I want to emphasize that within that program there is a 28 percent increase for the pre-college area and, in particular, a focus on improving the qualifications of teachers of that area. I believe that is the crucial nexus of this problem and the point of attack where we can make the greatest impact.

So let me then, if I may, Mr. Chairman, turn quickly to some of the highlights of the budget. I have just touched on four of the basic criteria we used in putting this budget together. The first area of emphasis I would touch on—not surprisingly perhaps—is basic research, because basic research underlies all else that we do in science and technology.

In fiscal year 1992, the budget that we have submitted to you has several specific programs aimed at addressing the problem which both of us had brought forcibly to our attention at the AAAS meeting and at a great many other meetings, and that is the pain in the university community, the fact that so many of our young people feel that we are not supporting the individual investigator, small group investigator, at a level that would be appropriate.

We, in fact, in the administration agree that last year the balance that we always try to maintain between supporting the work that scientists and engineers try to do today against investing in the facilities that will take these same investigators to their frontiers five and 10 years from now was perhaps tilted a little toward the future investment. So we have specifically worked this year, in the 1992 budget, to address that and to increase the support for individual investigators in the nation's universities.

At the National Science Foundation, for example, the request is for an 18 percent increase, putting the NSF back on the doubling trajectory by 1994. And very important within that request is the specific request that 16 percent of that increase find its way down to the basic sciences—to chemistry, biology, physics, and astronomy, and so on—within the NSF, where that has tended not to happen in the past.

In addition, the NSF budget this year has a new and crucial request for $50 million to provide state-of-the-art instrumentation to our research universities, and this is on a 50/50 matching basis with non-Federal funding; I think that is important.

At the National Institutes of Health—and it is important to emphasize that between them NSF and NIH support more than three-quarters of the university research done in this country—at the NIH, funding would go up to just about $9 billion, and of that $9 billion, about $5 billion, representing a 9 percent increase, was allocated to research project grants, grants going out to the investigators in the nation's universities.

So this set of initiatives—and there are others in the other agencies that support the remainder of the program—will, I believe,

take a strong step toward redressing the problem that we have. But I would emphasize to you that we will never fully solve this problem, nor should we, that there will always be more people requesting funding than we can realistically expect to fund, and that reflects the demographics of our present situation. Eighty-seven percent of all the scientists and engineers who have ever lived are out there writing proposals, and less than 5 percent of the taxpayers, and that is a fundamental dichotomy that we must address together.

One of the important considerations in the ability of our universities to respond to the demands we make on them is this whole question of the adequacy of their research equipment and facilities. We are unique in the developed world in the demands we make on the universities, because we ask them both for new knowledge and for the young minds trained to use it. Other developed countries separate those two, and most of the new knowledge frequently comes from outside the university, from federal laboratories, national academies, or the private sector.

We, I think, can be very proud of the fact that the Federal procedures that were established back in 1946 for support of R&D have been responsible for the strength of our present enterprise, and we based our support of research from the Federal Government on one single factor, and that was excellence. We have tended, over the years, to allow other criteria to creep in and perhaps begin to erode that focus on excellence, and I believe that in the future we must again be sure that our focus, not to decry the importance of some of the other criteria, but that our focus must remain on excellence; it has served us well; it will continue to serve us well; and I speak of excellence as determined by peer review.

And I think that we have some very important programs. I would mention the EPSCOR program in the National Science Foundation and the fact that in this coming year we will expand that into NASA and into DOE, that at your request in the Congress, it is being requested in EPA, in Agriculture, in the Defense Department, and the NIH has been asked to really take a hard look at whether the EPSCOR type program, designed to bring geographically diverse effort to nationally competitive levels—whether, in fact, NIH could not be involved in that as well. And so important in all of this is a continuing focus on excellence; I can not emphasize that too strongly.

One of the problems that I think all of us recognize is that, when funds are short, there is a tendency for individual institutions sometimes to use other techniques to satisfy what they view as very important needs, and I would only submit that, without suggesting for a moment that it is not entirely correct and the prerogative of Congress to modify the structure of our program in the Nation, that it is important, to the extent that we possibly can, to be sure that we continue to focus on excellence and that merit review be involved wherever possible.

The budget that we have sent forward to you represents our best judgment in the administration as to the proper balance, using what we recognize to be very scarce resources that are available, and we believe that deviations from peer review tend to distort this balance, because sometimes the decisions are made very late in the

progress of the budget and there is little time to really adjust to retain and regain the balance.

Let me then turn to an area in which I have particular interest; that is technology development. When I first came to my office, one of my first initiatives was to bring aboard a presidentially appointed, Senate confirmed associate director, a very distinguished individual, Dr. William Phillips, as my associate director for industrial technology, and in doing so I wanted to send a message, first, that we were going to raise the image of T in OSTP, and, secondly, that the Bush administration meant business in terms of using our technology to improve our economic competitiveness and our national security.

There are several initiatives in the budget that address this whole question of technology. Applied research and development in the Federal sphere falls into several broad categories. One is the applied R&D that is required to fulfill the missions of the various agencies—health, in energy, in national security, and space. Another is the question of generic technology, the kind of technology that has application very broadly across our society, where no one institution or organization has any guarantee of getting an adequate return to justify, in itself, the investment that is required to move that technology forward in competitive fashion, and so here the administration has made it very clear.

The President, in this past year, has spoken a number of times about the responsibility of the Federal Government, in working with our private sector and working with you in the Congress, to make sure that the results of our investment in research and development are exploited more effectively, more rapidly, more widely, to the benefit of our Nation.

One of the very important areas here that I mentioned earlier, Mr. Chairman, is that in high performance computing and communications. The President has proposed a 30 percent increase in the support of this field in recognition of the importance of not only making this new power available to many more people in the nation but also to retaining what is still U.S. leadership in this very important field.

Another important example, of course, is in energy technology, and at this time, in fact, Admiral Watkins and the President are presenting the National Energy Strategy. The budget has a number of new initiatives that are keyed to that strategy to provide alternatives to petroleum, to increase the efficiency of energy use, and to advance new technologies that can have a major impact on the way we produce and the way we use energy. We are suggesting a 34 percent increase in our investment in this work on energy-related technologies.

Another area that finally we are beginning to recognize in this Nation is vitally important but one that was forgotten for a number of years is manufacturing. Manufacturing does matter, and we are in the budget making provision for investment in that. We propose to invest over a billion dollars in fiscal year 1992. About half of that supports procurement needs of Federal agencies, but the other half is focused specifically on the development of generic technologies, technologies that will move this Nation forward in areas that we perhaps can not even imagine right now, and

within the Department of Commerce the administration proposes a 15 percent increase for generic applied research and technology development.

Aeronautics, another area where we have led the world but where our leadership is in serious jeopardy, is an area of emphasis in this budget, a proposed increase of 13 percent.

In biotechnology, which I believe in the next few decades will play the role that the physics- and chemistry-based technologies played in the post-World War II period, we have an exciting frontier. The budget suggests a $4.1 billion allocation for that frontier. They are designed, again, to maintain what we still have as a leadership position but a leadership position that we could very easily lose.

And, finally, let me mention an area that is not related to a particular budget initiative, and that is the research and experimentation tax credit. In recent years, you in the Congress have extended this on an annual basis, and we are requesting this year that you consider making it permanent, and the reason for that is clearly that if an industry cannot plan on it being available for longer than a single year period, the advantage that is inherent in this legislation is not being fully realized, and so I would urge your consideration of the making of that credit permanent.

If I could then—and I must apologize, Mr. Chairman, I am taking longer than I had intended. I have very little more to say. I would like, before finishing, though, to mention one or two other items, with your permission.

One of the very important aspects of our work in technology and in applied research is the way that we choose to support that research and development. I am convinced that in order for us to be effective in the Federal Government, it is vitally important that we develop true partnerships, where we collaborate with the private sector and with universities. There has been much talk about that kind of partnership for as long as I can remember but not too much action, and I believe that we have now the attention of all sectors of the community, and, working together, I think we can make some real changes that will move this forward.

I think that Sematech, for example, charged with developing the manufacturing technologies that will move us into a totally new generation of semiconductor, is one example of the kind of activity that we in the U.S. can mount uniquely by bringing together the know-how, the technology, and the strength of our industrial sector to focus their attention to develop a critical mass and to compete with the best that the world can produce anywhere.

A second example in this same area is one related to the National Energy Strategy, and that is the new cooperative venture that has been set up by the Department of Energy, Ford, Chrysler, General Motors, a number of the battery manufacturers, to move us forward in an exciting frontier, that of electric vehicles, where we are within a factor of 2 of truly viable units.

In general, we have the opportunity, if we grasp it, to work together with our private sector companies, to develop strengths, to develop technologies, to use know-how that cannot be matched anywhere else on the planet. It is an opportunity to challenge, and it is one that we can easily miss.

In conclusion, I would simply say that, as I have mentioned many times over the past year, and as I have heard many of you in the room also mention, we as a nation are, despite our present budget increases and requests, seriously under-investing in science and technology, given the potential and given the opportunities that lie out there for us. The administration's proposed budget addresses many of these opportunities, and we believe that it is a step in the right direction but that there still will be an under-investment, and, Mr. Chairman, all of us in the administration look forward to working very closely with you, with your committee, and with the Congress generally over these coming months to try to see these steps moved forward into appropriations.

Mr. Chairman, thank you for the opportunity of appearing before you. I should be happy to try to answer your questions.

[The prepared statement of Dr. Bromley follows:]

EXECUTIVE OFFICE OF THE PRESIDENT
OFFICE OF SCIENCE AND TECHNOLOGY POLICY
WASHINGTON, D.C. 20506

RESEARCH AND DEVELOPMENT

IN THE PRESIDENT'S FY 1992 BUDGET

TESTIMONY

OF

D. ALLAN BROMLEY

DIRECTOR

OFFICE OF SCIENCE AND TECHNOLOGY POLICY

BEFORE THE

COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY

HOUSE OF REPRESENTATIVES

FEBRUARY 20, 1991

Mr. Chairman and members of the Committee:

I am pleased to have the opportunity to testify before you on the proposed budget for research and development in Fiscal Year 1992 and on the Administration's science and technology policies.

Research and development are given special emphasis in this year's budget, reflecting the Administration's overall emphasis on investing in the future. Like spending on education or preventive health care, the total amount spent on research and development can be expected to pay itself back many times over. Furthermore, the returns can be measured not only in economic terms but in terms of national security, environmental quality, intellectual and cultural vitality, and spiritual inspiration. The

opportunities before us are endless. If we choose not to grasp those opportunities, we resign ourselves to a future that will be less prosperous and less secure than it would otherwise be.

The President's FY 1992 budget proposes to spend $75.6 billion for research and development, including R&D facilities, an increase of 13 percent over the amount Congress appropriated for FY 1991. Defense-related R&D would rise 14.5 percent, to $43.3 billion; civilian R&D would go up 9.5 percent, to $28.8 billion. Funding for basic research is slated for an 8 percent increase, to over $13 billion, and support for R&D facilities would rise 15 percent, to over $3.5 billion.

I shall return to specific budget initiatives in a moment. But first I would like to spell out some of the criteria that are applied in arriving at a proposed R&D budget and the reasons why the Administration believes that these proposals deserve your support.

POLICY RATIONALES FOR INVESTING IN RESEARCH AND DEVELOPMENT

The rationales for investing in research and development can be divided into four broad and partially overlapping categories: (1) investing for the future, (2) meeting national needs, (3) exploring intellectual and physical frontiers, and (4) strengthening mathematics and science education.

Investing for the Future

In the first category, that of investing in the future, it has long been known that spending on research and development has a very high rate of return. Economists estimate that more than half of the per capita growth of the U.S. economy since the Great Depression has been due to "new knowledge," including the results of research and development. Evidence from the past four decades suggests that industry-financed R&D alone accounts for about one third of the annual average growth of productivity over that period.

Besides fostering economic growth, science and technology have helped to improve the quality of our lives. New vaccines and treatments for disease, greatly enhanced mobility, a wider range of foods and other products, improved accommodations, and new forms of recreation and entertainment have all made our lives more comfortable and more fulfilling.

Different kinds of research and development tend to have different kinds of returns. With basic research -- the majority of which is done by individual scientists and small groups of scientists at universities -- it is very difficult to predict when, where, and to whom the returns will eventually accrue. Yet even work that can seem highly abstract can have surprisingly immediate impacts. To take just one example, in 1968 Thomas Brock, a microbiologist at the University of Wisconsin, discovered a form of

bacteria in the thermal vents of Yellowstone that can survive at very high temperatures. From these bacteria an enzyme was extracted that is stable at near-boiling temperatures. Nearly two decades later this enzyme proved to be vital in the process known as the polymerase chain reaction, which is used to duplicate specific pieces of DNA. Today, PCR is the basis of a multimillion dollar business with applications ranging from the rapid diagnosis of disease to forensic medicine.

The economic return of academic research is not easy to quantify, but an initial attempt has been made by the distinguished economist Edwin Mansfield of the University of Pennsylvania. Looking specifically at research conducted at colleges and universities, he found an average social rate of return to past investments in R&D of 28 percent. Others have estimated rates of return from all R&D expenditures -- that is, basic and applied research and development -- ranging from 20 to 200 percent. In comparison, companies normally expect to receive returns on the order of 10 percent from investments in other areas such as plant and equipment.

Examples of research and development that lay the groundwork for future advances in both the public and private sectors can be found in many areas -- in agriculture, space science, mathematics, biology, chemistry, engineering, earth science, physics -- indeed, throughout all of science and technology. However, returns from research and development -- and particularly basic research -- are not instantaneous. Depending on the type of research and the field in which it is done, the payoff may not come for many years. This time lag underscores the importance of R&D as an investment in the future, wherein a lack of investment now may result in diminished productivity in the next generation. Furthermore, these shortfalls cannot be instantaneously reversed by spending when the problem is noticed. It is our vigilance now that will make future technological growth possible.

Meeting National Needs

Another criterion applied to proposed programs in science and technology is whether they meet a pressing national need of immediate importance. The President's FY 1992 budget provides continued and, where appropriate, increased support for a broad range of federal R&D activities that address identified needs in areas such as energy, the environment, national defense, advanced technology, and health.

Many kinds of research and development are required to meet these needs. As an example, I might cite the U.S. Global Change Research Program, for which the budget proposes a total of almost $1.2 billion, an increase of 24 percent or $232 million. This amount will rtually double the size of the program since it was started in fiscal year 1990. Much of this work is basic research designed to document, understand, and predict the functioning of the Earth system on a global scale, yet it still meets and immediate and pressing need: that of producing the scientific knowledge that world leaders and the general public need to address such issues as global climate change and ozone depletion.

Another example of civilian R&D that meets important national needs can be found in the initiative in high performance computing and communications proposed in this year's budget. The program is organized around a number of "grand challenges" -- critical unsolved problems that can be addressed through the power of high performance computing. Furthermore, the provision in the initiative of a nationwide research and education network is designed to make access available to educational institutions not only at the university level but also for precollege students. There is already evidence that in areas with a significant fraction of rural schools, access via high speed networks will open up new vistas for our children.

National security is the final example I might cite of a national need requiring both basic and applied research. The superiority of the current generation of U.S. military systems, as dramatically demonstrated by the Desert Storm activities, is a direct result of decisions made in years past to harness American technical creativity in the development of military systems of unparalleled performance and quality. Costly though some of these systems were, they are now saving the lives of Americans, our allies, and our adversaries.

As the United States enters the 1990s, the strength of our R&D in defense technologies must be sustained. To meet this need, the budget proposes an increase of over $5 billion, or 14 percent, to a total of $43 billion for both the Departments of Defense and Energy to meet national security R&D requirements. By far the largest portion of defense R&D goes for hardware development and the operation and support of development, test, and evaluation facilities. But defense R&D also includes funds to support the defense technology base through basic research (which is funded at $1 billion in FY 1992) and applied research (funded at $2.9 billion).

Exploring Intellectual and Physical Frontiers

By emphasizing the economic and social returns of R&D, I do not mean to imply that all research must have an immediately discernable payoff. We are by nature a curious and inquisitive species, and great nations thrive by fostering these basic human drives. When nations pull back from the frontiers -- intellectual or physical -- they tend to decline. If we are to prepare for what the President has called "the next American century," we must continue to pursue the frontiers, as we have throughout this nation's history.

Few frontiers have ever been as dynamic and as full of promise as science is today. The number of opportunities in science is unparalleled, partially because past funding for research and development has opened up a wide variety of new areas of inquiry. For the past several centuries, the quest for scientific understanding has been one of the greatest adventures available to mankind. It is an adventure that has fundamentally changed our view of ourselves and the world around us, and it will continue to do so in the future.

The challenge of exploring new frontiers is one justification for human expansion into

space. Our standing as a world leader will continue to be measured, in part, through the commitment we make to exploring the space frontier. In addition, space exploration provides more tangible benefits in the form of new products and processes for industry and government, a stronger scientific and technological base, and a focus of attention for scientists and nonscientists alike.

Over the past year, the U.S. space program has been undergoing an intensive and very healthy review, and as a result the program is undergoing important changes. These changes, to which I shall return later, can be expected to produce a greatly strengthened space program.

Strengthening Mathematics and Science Education

A final criterion to be applied to prospective programs in science and technology is whether they act to strengthen mathematics and science education. Today, a large portion of the funds spent to support research and development have the ancillary benefit of either directly or indirectly supporting mathematics and science education. Graduate students are supported directly through fellowships and traineeships. Graduate students, and in some cases undergraduates, may also be supported under a research project grant given to an individual investigator. And the results of scientific and technical investigations, through their dissemination within the scientific community and to the general public, can generate greater interest in and understanding of science.

A technically sophisticated workforce, including scientists, engineers, technicians, teachers, and other trained personnel, is essential for U.S. competitiveness and an improved quality of life. Yet mathematics and science education in this country faces a crisis. Graduate education at U.S. colleges and universities remains the best in the world. Undergraduate mathematics and science education has peaks of excellence and valleys of mediocrity. At the precollege level, mathematics and science achievement in the United States is a disgrace, with American students typically scoring at or near the bottom in international comparisons of industrialized countries.

The nation is now recognizing the gravity of the problems affecting precollege education in science and mathematics. Within the federal government, a groundbreaking interagency effort has been working to maximize the effectiveness of the federal contribution to science and mathematics education, as I shall discuss below.

HIGHLIGHTS OF THE BUDGET

Having established some of the criteria applied in judging science programs, let me describe some of the areas of emphasis in the FY 1992 R&D budget and some of the issues that arise in considering the nature of that support.

Basic Research

The first area of emphasis in the budget is basic research. Basic research accounts for less than 10 percent of all the research and development done in the United States. But basic research -- and particularly the large fraction of basic research done in universities and colleges -- is an indispensable part of the nation's R&D enterprise. Indeed, it is the wellspring from which new knowledge and technical advances flow.

The federal government now supports more principal investigators at universities than ever before, reflecting real increases in the level of federal support for academic research. However, the number of such researchers competing for funds has increased even faster, which is largely a result of the emergence of exciting new scientific opportunities and past successes in training high-quality doctoral-level scientists and engineers. There has also been pressure to increase the size of such individual investigator grants -- reflecting the increased complexity of science (sophistication inflation) -- and to extend the duration of grants -- to promote stability of support and to reduce the fraction of researchers' time and effort devoted to paperwork rather than research. Both of these changes increase out-year mortgages. Such factors have caused the competition for available research funds at agencies such as the National Science Foundation and the National Institutes of Health to become so great that the situation has become a matter of serious concern to the research community in general.

Recognizing the many essential contributions of basic research, especially at universities, to our national future, the Fiscal Year 1992 budget proposes actions in several federal agencies designed to strengthen the individual and small group investigator component of the scientific enterprise. At the National Science Foundation, the President has reiterated his commitment to double the NSF's budget between 1988 and 1994. The budget proposes an 18 percent increase -- over $400 million -- for NSF, bringing it to a total of $2.72 billion. Support for the conduct of research, almost all of which is basic research in NSF, will increase by $284 million, or 16 percent, to a total of $2.1 billion. I sincerely hope that, this year, Congress will be able to sustain these increases, especially given that in recent years appropriations for research activities at NSF have fallen short of the increases needed.

In addition, the budget proposes a crucial $50 million initiative at NSF -- matched at least 50:50 by nonfederal funds -- to improve the research infrastructure by providing state-of-the-art instrumentation to university researchers. As with research funding, support for this instrumentation will be distributed on the basis of a competitive, merit-reviewed process.

At the National Institutes of Health, the President has proposed an increase of $334 million for basic research, or 7 percent, to a total of about $5 billion. Total funding for NIH would go up 6 percent to about $8.8 billion, and total funding for R&D within the Department of Health and Human Services would also rise 6 percent to a

total of about $10 billion. These amounts would allow for an increase of 9 percent in NIH's funding for research project grants awarded to individual investigators, providing for a broad base of fundamental advances. In addition, within the NIH total, $110 million is allocated to the Human Genome Program, with an additional $59 million in funding from the Department of Energy, resulting in an overall increase for the program of 26 percent.

Together, NSF and NIH support over half of the federally funded basic research done in the United States, and over 75 percent of the federally funded basic research done in universities. By focusing special attention on these agencies, the Administration plans to strengthen the individual investigator and small group research that remains the heart and backbone of American science and technology.

In other agencies, the budget calls for the Department of Energy to fund $1.76 billion of basic research into biological, environmental, and basic energy science and into nuclear and high energy physics. Funding for the Superconducting Super Collider is set at $534 million for FY 1992. This total is $291 million above the amount appropriated in fiscal year 1991 and will allow the SSC to proceed on schedule.

At the Department of Agriculture, the National Research Initiative, which is a merit-based competitive research grants program open to investigators across the nation, is proposed to increase by 71 percent, to $125 million. This program will broaden the nation's science and technology base through research in such areas as food safety, water quality, global change, pest management, and farm income. In addition, the budget proposes a $25 million facilities program at USDA associated with the National Research Initiative.

Finally, science research in the National Aeronautics and Space Administration is slated to rise by $262 million -- to a total of $1.96 billion -- largely reflecting increases in space and environmental science. These funds will support an exciting program of ongoing investigations, including studies using the Hubble Space Telescope, the Gamma Ray Observatory to be launched later this spring, and continued construction of the CRAF/Cassini probes and the Advanced X-Ray Astronomy Facility.

Research Infrastructure

One important consideration in the ability of universities to perform research efficiently and effectively is the adequacy of their research facilities and equipment. To sustain a strong national research capability and to expand the nation's research capacity, the R&D infrastructure must be maintained and replenished.

Since federal procedures were established for the support of R&D following World War II, the overwhelming majority of federal funds for research at universities has been allocated on the basis of excellence, as determined by a competitive process of

peer review. This approach serves to maximize the potential return on these investments by selecting only the highest quality research for support. Even programs that are more directed, such as the Experimental Program to Stimulate Competitive Research (EPSCoR), which is designed to bring geographically diverse research efforts to nationally competitive levels, are focused on excellence in that scientific merit remains a primary criterion for selection among eligible projects.

In recent years, the focus on excellence has been increasingly threatened by the practice of Congressional earmarking of funds for specific projects. According to an analysis of the FY 1991 budget conducted within my office, about $427 million was appropriated for such projects at universities in 1991. Earmarked projects typically do not undergo merit review, and thus their potential for contributing to scientific advance is often unknown. In the present era of tight budgets and spending caps, earmarking has the effect of substituting projects of unknown scientific merit for ones that have had careful examination of their scientific merits and thus threatens to weaken the nation's R&D effort.

The budget sent to Capitol Hill each year for research and development represents the Administration's best judgment as to the proper balance in using scarce resources. Earmarking distorts this balance. The Administration looks forward to working with you on ways to reduce the perceived need for earmarking.

Technology Development

Applied research and development activities funded by the federal government fall into several broad categories. One category is applied R&D that supports agency missions in such areas as national security, health, energy, and space. Another is applied R&D aimed at generic or enabling technologies that have many applications in the public and private sectors. Because of the many benefits to be gained by supporting this work, the budget provides increased funding for major areas of applied research and development.

An excellent example is the Presidential initiative in high performance computing and communications proposed in this year's budget. The President has proposed an increase of $149 million or 30 percent -- to a total of $638 million -- for an interagency effort designed to extend U.S. leadership in all advanced areas of high performance computing and networking. The program underlying this initiative has been put together by FCCSET's Committee on Physical, Mathematical, and Engineering Sciences.

Part of this program consists of basic research at the nation's universities designed to develop the hardware, software, networks, and human resources needed to ensure American leadership in all advanced areas of computing and networking. An additional and very important component of the program consists of applied research and development of generic, precompetitive technologies that will form the basis for tomorrow's computer and communications industries.

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Another important example of federal applied research and technology development -- particularly given the events of the past few weeks and months -- is targeted high-payoff energy technologies. Guided by the National Energy Strategy, the budget proposes a major initiative to develop technologies that could increase the efficiency of energy use, provide alternatives to petroleum, and advance new electricity technologies. About $900 million -- an increase of 34 percent -- is proposed for this work.

In the area of advanced manufacturing and materials, the budget proposes to invest about $1.3 billion, including over $1 billion for research and development on advanced manufacturing technologies. About half of this manufacturing R&D supports the procurement needs of government programs, but the other half is focused specifically on generic manufacturing technologies. An increase of 15 percent is proposed for civilian manufacturing R&D. In the area of materials research and development, the budget proposes $84 million for a new initiative in the National Science Foundation intended to strengthen the position of the United States in next-generation materials synthesis and processing. Initially, two high-payoff areas will be emphasized: electronic and photonic materials, and biomaterials.

Within the Department of Commerce, and specifically within the National Institute of Standards and Technology, the Administration proposes a 15 percent increase, to a total of $248 million, to expand NIST's ability to perform generic applied research and technology development and to address a rapidly growing number of important standards and measurement issues. Long-term projections for NIST call for a budget that is approximately doubled by 1996. These increase will allow NIST to conduct research and provide laboratory support for manufacturing technologies, information technologies, and other emerging technologies that are extremely important to the U.S. economy. In addition, the FY 1992 budget includes $36 million for the Advanced Technology Program to help fund industry-led high-risk R&D on precompetitive technologies.

To extend U.S. leadership in aeronautics, the budget proposes $543 million for aeronautics research and development in NASA, an increase of 13 percent. The program will address, among other items, high-temperature engines, issues associated with supersonic flight, and the aging of today's aircraft. In addition to this work, the budget proposes $305 million for the National Aerospace Plane (NASP), a joint NASA-DOD program, for technology development leading to a 1993 decision on an experimental flight research vehicle. Investments in NASP and enabling technologies are vital to future generations of military and civilian aircraft and to U.S. preeminence in these critical markets.

Biotechnology has become one of the most exciting frontiers in science, offering enormous potential in medicine, agriculture, and industry. In the budget, the President has allocated $4.1 billion to support biotechnology R&D. Over 80 percent of this amount is in the NIH budget, largely in the form of basic research, but 11 other agencies also support programs directly or indirectly related to biotechnology.

The budget's emphasis in this area is designed to maintain America's lead in this rapidly growing field and, at the same time, generate fundamental advances in such areas as gene therapy, agriculture, and environmental cleanup.

Finally, let me mention a related item that does not directly involve federal outlays but has a key effect on our ability to secure R&D investments in the future. For the past several years, Congress has been renewing the research and experimentation tax credit on an annual basis, but it has never made the credit permanent, and this has greatly diminished the credit's effectiveness. The Administration is again calling on Congress to make the tax credit permanent this year to help reverse the recent leveling-off of corporate R&D investment and expand its scope.

The Organization of Applied Research and Development

In the government's support of applied research and technology development, an important factor is the way that it chooses to support that R&D. The technology initiatives cited above tend to be most effective when pursued through collaborative, cost-shared efforts among government, industry, and universities. Where appropriate, R&D should be industry-led with cost sharing and a division of research activities among industry, universities, and government labs. The formation of industry R&D consortia is another way to encourage private sector-public sector cooperation. Examples of such cooperation are SEMATECH and a new venture involving the Department of Energy, Ford, General Motors, Chrysler, and EPRI on R&D on batteries for electric vehicles. By pooling resources, individual participants do not each have to reinvent the technological wheel but have access to the results of efforts that are several times the investment of any single company.

Together, these organizational arrangements are designed to foster a new, more results-oriented approach to technology development. They have the effect of building technology transfer into the process from the outset rather than attempting to weld it on at the tail end of a project. These issues are discussed further in the publication "U.S. Technology Policy" released last September by OSTP.

Research on generic or enabling technologies produces results that will most likely be applicable to other problems, firms, and industries beyond those involved in the joint venture. These indirect or downstream benefits are a key rationale for government involvement. In the computer industry, for example, increases in productivity and capacity brought about by SEMATECH directly benefit the computer industry by increasing its productivity and indirectly benefit other companies through the provision of cheaper and more reliable computing power.

In parallel with the efforts to find more effective ways of funding applied R&D, the Administration is acting to improve coordination among the federal agencies that support this research. This coordinating function is being pursued by the Federal Coordinating Council for Science, Engineering, and Technology -- the interagency forum of Cabinet secretaries, deputy secretaries, and the heads of independent

agencies that reviews, integrates, and helps to implement federal science and technology policy. Following its reorganization and revitalization last year, FCCSET has initiated and extended a number of activities in high-priority, cross-cutting areas of science and technology, some of which are directly related to the budget and some of which involve nonbudgetary issues.

In addition, the National Critical Technologies Panel formed under the auspices of OSTP has been examining technologies important to the future economic health and national security of the United States. The Critical Technologies Institute, which OSTP is in the process of establishing as directed by Congress, will assist in the development of strategies that will follow up on the panel's work in these critical areas.

Finally, the President's Council of Advisors on Science and Technology (PCAST) has been meeting monthly with the President and with senior members of the White House staff for much of the last year. PCAST has helped to bring the private sector's perspective to the federal science and technology policy process at the highest level, and the deliberations of this group are having an important influence on federal science and technology policy.

Expanding the Geographic Frontier: Space Exploration

This year's budget makes a very strong commitment to the scientific components of the space program, in keeping with the report of the Advisory Committee on the Future of the U.S. Space Program (the Augustine report). It proposes $2.1 billion, an increase of 21 percent over FY 1991, for NASA's space science programs, including astronomy, life sciences, planetary exploration, Earth science, and materials research. This represents about 20 percent of NASA's total budget, which is also in keeping with the Augustine Report.

NASA's proposed $15.7 billion budget also includes support for a Mission To Planet Earth and a Mission From Planet Earth. The Mission to Planet Earth is a vital component of the nation's overall integrated global change program. It includes initial support for the Earth Observing System (EOS), which, for the first time, will make simultaneous observations of the earth's surface by a whole suite of complementary instruments. EOS is an integral part of the U.S. Global Change Research Program coordinated by FCCSET's Committee on Earth and Environmental Sciences.

The Mission from Planet Earth -- which includes Space Station Freedom and the Space Exploration Initiative -- supports the goal of expanding the human presence away from Earth and into the solar system. Continued development work on Space Station Freedom is funded at about $2 billion, taking into account the ongoing modification of the station to focus on life sciences and microgravity and reduce its operational complexity. The Space Exploration Initiative is funded at about $250 million, including activities in the Departments of Energy and Defense, and as

recommended in the Augustine Report is being planned on a "go-as-you-pay" basis.

The budget also recognizes the critical importance of space transportation as the foundation of all U.S. space activities. The budget proposes $350 million (split evenly between DOD and NASA) to continue advanced rocket engine development and to initiate a program that will culminate in the development of a new space launch system. The program's goal is to provide new launch capability for a range of payloads, including heavy-lift, that is both more capable and more cost-effective than today's systems and that will benefit both unmanned and manned space activities.

Mathematics and Science Education

Over the past year, FCCSET's Committee on Education and Human Resources, which is chaired by Secretary of Energy James Watkins and vice-chaired by Ted Sanders of the Department of Energy and Luther Williams of the National Science Foundation, has been examining the federal government's support of science and mathematics education. Guided by the National Education Goals established by the President and the nation's governors, the committee has developed a strategy to maximize the effectiveness of the Federal contribution to American science and mathematics education.

The recently released report of the committee, entitled "By the Year 2000: First in the World," lays out strategic priorities designed to meet the educational needs of the country in this area. At the precollege level, which the report identifies as the highest priority for action, the greatest need is to increase the supply of well-trained science and mathematics teachers. Other areas of emphasis include improving curricula, developing new educational technologies, and increasing student interest and performance in science and mathematics, particularly among women and minorities. Similar strategic priorities have been developed for undergraduate and graduate education. It is important that in our efforts to correct a dismaying series of problems at the precollege level we not lose sight of the importance of maintaining our world leadership in graduate education.

The committee also presents, for the first time, a comprehensive interagency overview of federal funding and programs that affect science and mathematics education at all levels -- precollege, undergraduate, and graduate. The federal investments in science and mathematics education are larger than previously recognized: in fiscal year 1991, for example, the federal government spent $1.7 billion expressly for science, mathematics, engineering, and technology education at all levels.

The FY 1992 budget proposes that the federal government increase this amount by over 13 percent, to about $1.94 billion, as part of an integrated interagency effort in science and mathematics education. Precollege education would receive the largest increase -- $146 million, or 28 percent.

This report by Admiral Watkin's committee breaks new ground and will greatly

influence our national strategy in science and mathematics education.

CONCLUSION

I have often said during this past year that the United States, in both the public and private sectors, is underinvesting in research and development. This belief is widely shared in the Administration, and I know that it is widely shared here on Capitol Hill, as demonstrated by the solid increases appropriated to science and technology by Congress last year.

The Administration's proposed FY 1992 budget for research and development continues to take steps to address this underinvestment in science and technology. We in the Administration plan to work closely with you in the Congress over the coming months to see that these proposals are translated into appropriations.

That concludes my testimony. I would be very happy to answer your questions.

The CHAIRMAN. We thank you very much, Dr. Bromley.

I am going to recognize Mr. Valentine first.

Mr. Valentine.

Mr. VALENTINE. Thank you, Mr. Chairman.

Dr. Bromley, let me say to you that I think the Chairman's statement about your presentation is one of the greatest compliments that you could receive, because he has seen—he has read a lot of opening statements, and he has heard a lot of opening statements in the past 20 or so years.

I have one or two questions that I would like to ask you having to do with the administration's technology policy and the role that the Federal Government should play—that you think the Federal Government should play in converting scientific research into technology advancement and related matters, but I am afraid that I might run out of time before I ask you this question, so I want to put it first.

You are now part of the Washington gang, you know; you are one of the villains, by virtue of the fact that you work for the President, the executive branch, and that makes you one of those guys in Washington that won't solve the national problems. You come here and tell us about a lot of things that the country should do in the area of technology and competitiveness and scientific achievement and list what the President would like to see the Congress do with respect to SSC, additional funding for SDI and NASA and the space station, a 13 percent increase in R&D spending for one source, a 21 percent increase in another, and since we met last we have got ourselves into a shooting war, which I think is a just cause, where we shoot out projectiles that would pay the tuition for two dozen students for four years at Duke University.

When you talk to the President and you have his ear, ask him to come to Congress and recommend to us that we all sacrifice, that he recommend to us a war tax so that we can pay for the war and do these things that you are talking about, because, you know, we are all grown folks. There is just no way that we can meet the goals, that we can do what we need to do to improve the competitive situation of this country, that we can come anywhere close to what you are talking about and pay for the war, too. How can we do that? And here is a time when we are talking about sacrifice, when we have men and women exposed to danger and it is business as usual for the rest of us—nothing. I beg you to talk to him and tell him that there is at least some sentiment here for that type of leadership.

Now my question. Can you give us, in a few words, what you think, Doctor—and, incidentally, in my limited experience here, I think that you have done an exceptional job, and I appreciate the way you approach the tasks assigned to you; I appreciate your many courtesies to me, your openness.

What role do you think the Federal Government should play in converting scientific research into technological advancement?

Dr. BROMLEY. Thank you, Mr. Valentine.

I think that we have a very important role to play, because—

Mr. VALENTINE. Of course, you feel free to comment on my statement, if you would like to, also.

Dr. BROMLEY. Let me begin, sir, by attempting to answer the question.

I think we have a very important role to play because, first of all, we have to recognize that we are now very firmly part of an international marketplace and that in the major countries with whom we compete the governments of those countries have forged very strong links with their industrial organizations and that together they put federal monies, industrial monies, sometimes all sorts of monies, into very focused, targeted programs to develop technologies that are going to be important in terms of economic competitiveness, and by doing that, they share the risk, they speed up the process, and they minimize the cost to the individual participant.

Now if we are going to compete in that international marketplace, it seems clear to me that we, too, must enable our competing companies to avoid having to reinvent the technological wheel, whatever it is, individually, in parallel, because under those circumstances we simply can not compete, and so I believe that the Federal Government has as its primary role that of a catalyst, that of bringing together a critical mass of the private sector—industries, groups interested in a particular area—working with them, working with universities to develop a really coherent, sensible plan to move the United States forward into a leadership position and, where necessary, the injection of Federal funding to help this program move forward.

Now there has been tremendous confusion as to where we are in technology policy and industrial policy, and let me try to sort that out just very briefly. On the one end of the spectrum is basic research. No one questions there that there is a major role for the Federal Government, because since one can not project where the returns come or when, no individual organization can afford to make the investment necessary.

I would submit, sir, that the same thing is true in the generic technology area, much more true now than it ever was before, and that up through the whole development of the technologies until you are ready to produce a product or a process in the marketplace, that we in the Federal Government have a role. I do not believe that we have a role in the marketplace itself—for example, in a particular industrial sector, picking a particular company for support as opposed to other companies in that sector—because, frankly, I do not think that we in the administration are any smarter or nearly as smart as the people in that sector who can make the decisions better than we can.

Mr. VALENTINE. Thank you.

Mr. Chairman, I heard the gong. Thank you very much.

The CHAIRMAN. Thank you, Mr. Valentine.

Mr. Rhodes, you are the next one on my list.

Mr. RHODES. Thank you, Mr. Chairman.

I do not know about virtue having its rewards, but, clearly, being early does.

Dr. Bromley, I join with my colleagues in my admiration for your testimony and for the administration's budget proposals on this subject, and I appreciate it, and I wanted to say that at the outset because I think I am going to take issue with you on one particular

point, and I do not want you to misinterpret that in any way, and that point, Doctor, is the issue of excellence, merit, and peer review.

In your written statement, you actually use the word "earmarking." I noticed you carefully avoided it in your oral testimony, probably because it is a word that should not be used in polite mixed company.

But, you know, it seems to many that the merit peer review system—and you have heard all this before—is sort of an old boys' excellence network; it is kind of like a private technological country club where strange people like land grant colleges and state universities do not need to apply; and that causes some problems up here, as you mentioned in your testimony.

But my basic question to you, Doctor, is, isn't the encouragement of the development of excellence not only a legitimate but perhaps even a vitally necessary function of the Federal research and development effort?

You know, I happen to be a graduate of a university, an eastern private university, that benefits greatly by merit and peer review. In my State of Arizona, we have two great universities that are developing major research capabilities, but they are strange people on the block, they do not need to apply under merit and peer review, they rely heavily on their Congressional delegation helping them earmark, and they are using those capabilities to develop excellence.

Well, my question is obvious. Is not the development of new excellence just as legitimate an R&D effort as the reward for old excellence?

Dr. BROMLEY. Mr. Rhodes, I have no argument with you at all on that one, because I, too, believe that we have a major responsibility to broaden the distribution of excellence. That is why, for example, I am a very strong supporter of the EPSCoR approach, where we encourage universities that are not at a competitive level at the moment to apply for help from the Federal Government to bring them up to a level where they can compete with anybody, and I want to see that kind of program spread from the NSF through the other agencies, because it is very important, and I think there is an underlying myth that is very important, that we get out on the table, that has been with us since the end of World War II. That myth is that the Federal Government does not support higher education, and, in fact, we all know that literally tens of thousands of graduate students are supported through research grants and contracts each year.

But what we forget is that something—well over 50 percent of all the young people in this country go to college or university within 100 miles of the spot where they were born, and that to me means that we have a real responsibility in the Federal Government to provide high quality educational opportunities widely distributed. It also means to me, because I believe that you can not have that high quality educational activity unless you have some high quality research in the institution, some real contact with today's frontiers, that we have to develop that much more widely.

What I do not want to see—and I am not for a moment suggesting, sir, that this is the case in the institutions that you mention,

because I know these institutions very well—I do not, however, wish to see us in the position where we support less than excellent research, because that kind of activity does not do any good for education, nor does it do anything for economic development.

So I think you are on exactly the same track that I am—namely, we have got to broaden the distribution of excellence. I think we are working on it; we have made a start, a good start. I am particularly impressed by the fact that the funding from the NSF is leveraged by a factor of about 3 from the particular states that are involved in that program, and in getting that factor of 3 leveraging there is a quality control that the individual States exert on the whole program that is very important.

Mr. RHODES. Doctor, I appreciate your answer, and I would like to assure you of one thing. I think probably all of us are very troubled by the practice of earmarking. I think that most of us would not like to continue being in a position of having to impose our very unknowledgeable judgment on where R&D funds ought to go, and I think there is another myth that perhaps we could begin working on dispelling, and that is—if it is a myth—that the merit and peer review system is, in fact, an old boy network. If it is more open, if it is more competitive, than we all are led to believe, then perhaps we could remove the burden of our having to make earmarking decisions from ourselves and put it back into the network.

Dr. BROMLEY. If I could, sir, as a 35-year veteran of the peer review wars, I would have to quote an abridged version of Winston Churchill. You will recall his comment about democracy—it was a terrible system, but it was the best by far of all the alternatives—and, quite frankly, I believe deeply that the peer review system, with all its flaws—and it has flaws—is still the best system we have of sorting out and identifying excellence, and I think that it is not an old boys' network, despite many claims in that direction.

Mr. RHODES. Thank you, Dr. Bromley.

Thank you, Mr. Chairman.

The CHAIRMAN. Dr. Bromley, let me just follow up briefly on that question, because you address it in your own statement somewhat. There are provisions there for increasing the funding and for research facilities and equipment, but in one situation you have actually eliminated the funding that would support that program, and I think the justification was that the need could be met through the universities' depreciation accounts, which they take out of their research grants.

Now that does not do justice to those universities which do not have huge volumes of grants, and one of the suggestions that has been made by a number of us in Congress is that the President have a somewhat more robust program of funding admittedly decaying research facilities and equipment, and that that would help to obviate this earmarking. Do you see any possibility that we can move a little more vigorously in this direction?

Dr. BROMLEY. Yes, Mr. Chairman, I do.

I want, first of all, if I might, to answer it in two parts. The first part is to emphasize that we did ask for $50 million additional with 50/50 non-Federal matching to provide new research instrumentation to the universities. That is a start in the right direction.

The CHAIRMAN. Yes. That is limited to research instrumentation.

Dr. BROMLEY. Yes, you are quite right, sir.

You will remember, sir, that in 1986 David Packard and I produced a report on the health of U.S. colleges and universities, and in that report we addressed head on this very difficult question that results from more than a decade of deferred maintenance, modernization, and so on, in the nation's universities.

I have not changed my mind at all from the time when we wrote that report. I still consider this a very important problem and one that must be addressed, because I do not believe that the cash flow from use charges, and amortization charges, and so on, can, starting from where we are now, do the job. I believe that we have a quite defined catch-up problem to get the infrastructure back to a level that we would consider acceptable, and then we must work out a gentleman's agreement with the universities so that, from there on, they would agree to put the funds that they get for amortization and use charges in a sequestered account that would be used for that purpose rather than put into the general accounts with the hope that a philanthropist would appear on the horizon when the need is desperate.

The CHAIRMAN. Well, I am glad you have not forgotten the findings that you produced just a few short years ago and that you will continue to work on that.

Mr. Swett, you are the next one in line.

Mr. SWETT. Thank you very much, Mr. Chairman.

Dr. Bromley, it is indeed a pleasure to be able to confer with you this afternoon. I am very interested in hearing your responses to the questions that I have.

I would like to start by saying that, although I was not fortunate enough to be a student of yours, I, too, like my good colleague from Texas, started my career as an aspiring physician, and the rigors of the discipline also convinced me that I might find an easier route combining that with art in the form of architecture.

I will give you a little background just to give you certainly the angle of my perspective. I ultimately did end up in the private sector as an engineer developing alternative energy and cogeneration facilities and had the great opportunity of traveling throughout the country looking at the industrial facilities of this nation and trying to address in those facilities the idea of conservation through the use of alternative fuels and cogeneration, and, quite frankly, I came across a situation that I found extremely deplorable. That fact, plus the fact that in that pursuit I realized how political that pursuit really was, is what brought me here to this committee on technology and is the main driving force behind my interest in this field.

As I look at the problems that we have facing us, I really identify two areas that I see as predominantly of interest, and one is, as we discuss the research and development areas, in particular surrounding energy research, it is my question to you, are we dealing with the proper mix of alternative fuels and the use of those fuels through conservation efforts, or are we, as I am afraid, focusing primarily on the fossil fuel and nuclear approach?

And before you give me an answer to that, I will just give you the other area so that you can cover both questions in one answer, and that is, as we focus on providing funding for the very impor-

tant pre-college education phase of our students in this country, my question is, are we, in fact, putting enough emphasis on that area? And what emphasis that we do place on that seems to be insufficient in terms of the kinds of funds that are being made available for that development. And I would like your comment on how you see this investment being made in an effective and efficient manner so that we are getting the maximum bang for our buck in those areas.

Dr. BROMLEY. Thank you. Those are both excellent questions. Let me try to respond to them.

In the first area, the question of alternative energy, we recognize that in our primary energy spectrum at the moment, 40 percent comes from petroleum and something like 8 percent from alternatives, taken together, and I include here methanol, ethanol, biomass. Nuclear is different; nuclear provides something about 7 percent of our current primary energy. And we have solar playing a substantially smaller role; wind, a vastly smaller role still; there are a whole spectrum of these.

Now I agree that we are in a situation, in my view, where we have long since frittered away the time that should have allowed us to do more development than we have done, and so that we are now in a position where we do not have the luxury of picking one or another approach to our energy problem, we have to use all of the approaches that are economically viable.

That means that there are a lot of these sources—wind, solar, geothermal, ocean thermo-gradient—all of these, that are going to play a role, and we have to develop them, they need the research and development, but fundamentally I think they are going to be niche energy supplies, very important ones. But in terms of major supply, first of all we talk about electricity, because although our energy—primary energy utilization has tended to be relatively stable since about 1974, our electrical energy consumption has grown right along with the GNP, and so it is electrical energy that we really have to focus on.

There, sir, I believe that the only real alternative that we have available right now for producing large blocks of electrical energy is the nuclear fission option, but we have not done it well in this country, and I do not think we can ask our public to go forward with an aggressive energy program involving nuclear fission until such time as we produce and demonstrate to them that we have produced intrinsically safe modular units that can be certified and produced in a standard fashion for utility use as needed.

So there is a gap, and in that gap we are going to have to use all of the possible alternative fuels that we can come up with. We are making a real attempt in the National Energy Strategy to induce organizations that have more than 10 vehicles in urban centers, more than 20 vehicles in the country generally, to really focus on alternative fuels, and I think perhaps the most exciting option that is out there is the possibility of, in the long run, moving us away from petroleum-based transportation fuels. We are within a factor of 2 of having economically viable electric vehicles, and that is where this consortium I mentioned, I think, has a major role to play.

So I agree with you that these are very important; they are included in our proposal to you; they are going to be emphasized in the National Energy Strategy; and the most important effective alternative fuel we have in the nation is conservation, because we use our electricity more efficiently, and we have tremendous opportunities for doing that in a building like this, for example, where the lighting is probably something like 4 percent efficient. We have a long way to go. In industrial processes, where we alone in the developed world did not put energy in the equation that we optimized to develop our process, we have a long way to go.

Let me turn then, if I might, to your second question, and that is, are we putting the money where we should in the pre-college problem?

The CHAIRMAN. Let me interrupt you just briefly.

There is a roll call on. I am going to recommend that Members go and respond to the roll call and return as quickly as possible. I will remain here until somebody gets back who can chair, so that we can be as easy as possible on Dr. Bromley's time.

Now you may continue, Dr. Bromley.

Dr. BROMLEY. Thank you, Mr. Chairman.

We are, at the moment, in the Federal Government, through primarily chapter one of the Eisenhower Program in the Department of Education, currently spending about $2 billion a year toward science and mathematics education at the elementary level. We are also, this year, for the first time, requesting that you put into place a $40 million program that will be divided out among the States to reward schools that have really demonstrated already that they are making significant progress in improving their performance.

But most important of all, I think, is the fact that we are in the process of getting an executive order which will add education to the mission statement for all of the agencies. That means we can draw on the really remarkable resources that exist in the 726 National Laboratories, for example, that we have across the Nation, to bring those people in to working with the elementary schools to try to—it is not that we are going to try and teach the teachers how to teach better; that is not needed.

But what we can and must do on a fast turnaround is to motivate the teachers and motivate the students and get them excited, give them the feeling that there is an adventure here that they, too, can participate in, and the most important part of the whole thing, in my view, is, we have got to work to reinvolve parents in the education of their children, and if we can do that we will have taken a great step forward.

Mr. SWETT. Dr. Bromley, I thank you very much for your comments.

Certainly, Mr. Chairman, I have a great interest in this area, and I could speak with you for hours on this. Thank you very much. I appreciate your allowance of this time.

The CHAIRMAN. Mr. Swett, may I suggest that you take advantage, if you have not already, of the opportunity offered by Engineers Week to go out into a classroom and motivate the students a little bit.

Mr. SWETT. I might say that I have a program back in my district where, on a weekly basis, I teach a high school class.

The CHAIRMAN. Great.

Mr. SWETT. So I have already engaged myself.

The CHAIRMAN. Let us get that into the record. Maybe you could motivate some of our other colleagues.

Mr. Boehlert.

Mr. BOEHLERT. Thank you, Mr. Chairman.

Dr. Bromley, I am just very favorably impressed with the science budget in its totality, which I think is a tribute to the President and, in large measure, a tribute to you. But today, rather than talking about all the pluses there—and there are many pluses—I prefer to dwell a little bit on some of the disappointments, and I noticed in your written submission and also in your oral statement you were merciful, you spared us any of the hype on the Superconducting Supercollider. I do not know if that was intentional; I would like to think it was.

But let me ask you: Next year's budget request, a 120 percent increase for the Superconducting Supercollider, and two things have changed since the last year. One, the SSC cost estimate is now officially above $8.8 billion; that is the one they have released; the one that goes up higher than that they have not released yet; and this started out as a $4.4 billion project.

Given the growing cost of the SSC, what impact do you see the budget resolution having on our ability to press forward with the SSC, especially given the prior pledge that the SSC would not be built at the expense of other research programs?

Dr. BROMLEY. Mr. Boehlert, that is, as you fully recognize, a very difficult question. Let me try to respond, though, in detail.

First of all, you will recall that two Presidents and several committees of the Congress have given their approval to the SSC. But, as you correctly note, there are two provisos that have gone with each of those approvals. The first is that one-third of the cost be borne by non-Federal sources, and the second is that the project not go forward at the expense of the base program.

Now, the fact is that at the moment it is premature for us to expect to have the foreign commitments because the foreign governments are not going to make any commitments until such time as they see actual construction. That is not surprising. We would not do it either.

But, negotiations have—discussions and negotiations have been in progress with a number of potential foreign collaborators, and the Department of Energy has been moving aggressively in that direction.

The other proviso, I agree, sir, poses some very major difficulties, which I noted that Admiral Watkins in his testimony 2 days ago felt that he was unable to address. Because the cost to build the Superconducting Supercollider at the moment, as you say, is at $8.2 billion. The difference between the various cost estimates that have appeared depends primarily on how optimistic one is in terms of the construction schedule, how much one includes of the major detectors within the original construction budget, and thirdly, how large a contingency one is prepared to place, or how small a contingency one is prepared to place on the construction of this facility which really is going to be at technological frontiers.

Mr. BOEHLERT. If I may interrupt here. Admiral Watkins, isn't he the Cabinet officer that said we would not go forward if it cost one penny more than 5.9 billion?

[No response.]

Mr. BOEHLERT. Well, all right. I just want to add that in for the record.

Dr. BROMLEY. I am afraid that I was not present when that statement was made.

[Laughter.]

Dr. BROMLEY. The fact is, though, that given the budget agreement and given the cap on domestic discretionary spending, the resolution of the out-year mortgage costs of a whole series of major projects in which we are still engaged is not obvious, is not available, and I do not think that anyone at this point can answer it.

Now, the fact is, however, that as I have indicated earlier in my testimony, sir, I believe that we are underinvesting seriously in science and technology. Now, there is always the possibility that instead of being constructed at the expense of other parts of the science and technology budget that the proponents of SSC may be able to convince you and your colleagues that in fact some other area of discretionary domestic spending might in fact be more vulnerable.

Mr. BOEHLERT. Well, Dr. Bromley, I am concerned, for example, the ATP program—Advanced Technology Program—gets no increase; manufacturing technology centers take a hit; we zero out technology extension. I mean, you talk—there is a gap between your support for technology development and the movement of that technology out of the labs and into the marketplace, and I do not know how we can quite explain our priorities here when there is a conscious decision to pull back on technology transfer. That concerns me.

And then we have one project to get 120 percent increase in funding.

Dr. BROMLEY. If I may say, sir—first of all, just a small point. In the ATP program we have, in fact, increased it by a factor of 3.6 from $10 million to $36 million and I have just learned, in fact, today, to my great satisfaction, that in response to the request for proposals for that ATP initial 10 million, 4,000 requests for information and 249 proposals were received by NIST and the selection is now in its final stages. The $36 million I am sure will be looked at with equal enthusiasm. So I am all for that.

In terms of the SSC, let me simply say that it is the biggest program that has ever been proposed in any of the sciences anywhere at any time. It answers, or proposes to answer some of the most fundamental problems that remain in our knowledge of our universe. It is an absolute monument to the frontiers of technology. If we can build that and build it successfully, it demonstrates technological prowess of a rare kind. And it is the administration's position that at this time we are certainly moving forward as we have in the past with this program.

Mr. BOEHLERT. I just think it is rather significant that your written statement and your oral statement, both of which were quite detailed and were music to my ears, notably lacked any mention of the SSC. And maybe I am reading more into it, maybe it is just

wishful thinking, but I am glad you spared us that hype. I think we have got a long year ahead.

Are you confident in the new revised cost estimates? I mean, I have said before, Dr. Bromley, and we have talked about this, it is like the ante—the $4.4 billion is like the ante in a poker hand. Our hand is going to be called several times, and each time it is called it costs us a lot more to be in the pot.

Now, it is up over $8 billion and there is an in-house cost estimate that is over 11 billion. And where do we stop? I mean, where do we finally make a decision that this is too much?

Dr. BROMLEY. That is a decision, sir, that will necessarily be made by you and your colleagues. But the difference in these costs, as I have emphasized, is not so much that it is just that people can not estimate costs, but it depends on what you include in the package, whether you include detectors or you do not include detectors, whether you feel that a realistic construction schedule requires the addition of another year or whether you do not, what contingencies you put in. That is the reason for these differences. And I can not tell you what the actual cost will be. I do not think anyone can.

Mr. BOEHLERT. Well, Dr. Bromley, I am sure we will pursue this many times in the future. I have to run now because we have a resolution on the floor and about 2 minutes to vote. The resolution encourages Americans to display their flag proudly. It is going to pass by 400 and something to zero. It is what we do on the floor when we do not have anything else to do, and I am very patriotic.

Thank you, Dr. Bromley.

Mr. WOLPE. [ACTING CHAIRMAN]. Thank you very much, Mr. Boehlert.

Dr. Bromley, I am delighted to join in the welcome that has been extended to you today and have you before the committee.

I have to pick up on a comment that you made. I am sorry that you mentioned that the lighting here was some 4 percent efficient. I wondered if you were aware that one of the things that was cut out of the National Energy Strategy as it made the trip from the Department of Energy to the White House was the lighting efficiency standards that had been recommended by the Department of Energy.

Dr. BROMLEY. I was aware of that, sir.

[Laughter.]

Mr. WOLPE. I would also like to kind of really pick up on this question as your policy generally, and one specific aspect. In your own response earlier to, I think Mr. Valentine's question, you distinguished between—you tried to draw the line that distinguishes between federally supported technology development on the one hand and industrial policy on the other. The budget document this year tries to spell that out in much the same fashion that you did just now.

The question I have is whether you see that policy that you have articulated, how you see that squaring with the administration's efforts to revive the commercial nuclear power industry specifically? For example, the President's budget proposes a 117 percent increase for the Advanced Light Water Reactor Program. In its Fiscal 1992 Budget Summary the Secretary of Energy indicates that the purpose of this program is—and I quote him: "To make

commercially standardized advanced light water reactors available for orders by 1995. In Fiscal Year 1992 the program is cofunding work toward securing final design approval for the General Electric advanced boiling water reactor and resolving safety issues with the NRC for the combination engineering system, 80-plus advanced pressurized water reactor." The budget document goes on to predict that these efforts will—and I quote: "resolve problems which burdened the nuclear power industry in the past."

Dr. Bromley, the President's budget indicates some opposition, as you note earlier, to targeting specific industries with Federal research and development assistance to develop new products. Nonetheless, that same budget seems to me to clearly target the nuclear industry for special Federal assistance. I find it rather remarkable that the administration, proclaiming free market principles, would support millions of dollars in Federal subsidies to help individual corporations bring specific technologies into the marketplace. That sounds a lot like industrial policy to me or like picking winners and losers.

I wonder if you could kind of reconcile that apparent contradiction.

Dr. BROMLEY. I would certainly wish to try, sir. The fact is, as I think I mentioned earlier, that if you ask how we can reduce our dependence on petroleum, how we can reduce our emissions of carbon dioxide, and how we can continue to get electrical energy that is tracking our GNP growth, I am afraid that the only technological alternative that I see for large blocks of electrical energy at this time is nuclear fission. And the reason that we have not moved forward as have France and Japan and Germany, and many other nations, is because, as I said earlier, we I feel did very badly in our introduction of nuclear energy into our economy and we have to essentially start over.

But the reason that the Federal Government in the budget document that you have before you is suggesting substantial investment in advanced research on these new reactors is not because we are picking a particular set of purveyors of these nuclear units, but rather because we do not see any alternative that will allow us to replace petroleum, that will allow us to cut down our CO2 emissions for the next many decades.

Fusion is not going to do anything for us in terms of energy in the grid until sometime toward the middle of the next century.

Mr. WOLPE. Do you think nuclear power would be commercially viable without Federal subsidization?

Dr. BROMLEY. Nuclear power starting from where we are now would not be viable without some Federal input. No, I think that is quite true.

Mr. WOLPE. Why would one inherently be more supportive of providing subsidies to nuclear power than subsidization, for example, for efficiency, energy efficiency initiatives? As you know, those have also been—several energy efficiency initiatives such as weatherization funding and the like have also been deleted from the National Energy Strategy. Is there not an inconsistency? Is there not a double standard, if you will, being applied?

I mean, if the argument is let the free market do its thing, clearly we are not being very consistent in our approach to that, are we?

Dr. BROMLEY. I would not wish to claim that the National Energy Strategy or any of our policies are 100 plus percent internally consistent. But I do believe that the only alternative we have at the moment for large blocks of electrical energy is the nuclear one, and for that reason I believe that it is entirely appropriate for us to support this research.

Mr. WOLPE. But there has been substantial economic analysis over the past few years suggesting that if, in fact, we were to give comparable emphasis in government policy to the efficiency side of the equation and to certain renewables that, in fact, we could displace petroleum far more rapidly at far lower cost than would be involved in the effort of trying to prop up the nuclear power industry. And I just throw that out. I am not—it is not clear to me—I do not think what you are saying is really intuitively clear.

Dr. BROMLEY. I would not argue with you, sir, about the importance of efficiency. I fully support this, and that we must do everything we can to increase the efficiency of our utilization of electrical energy—all energies. I totally agree with you.

But even so, it is my belief, sir, and I think here is where we differ. That I believe, that even with the most aggressive increase in our energy efficiency that we still will have a gap that will require filling, and the only way that I see from a technological point of view of filling that gap in the near term is the nuclear option.

Mr. WOLPE. So the question still would present itself, even if that were true, granted the assumption for the moment for purposes of argument, why we would subsidize that and then eliminate the other on the grounds of a free market ideological thrust. That is the double standard of which I speak.

Dr. BROMLEY. Well, I understand your point, sir. But there is a very great amount of work being done on increasing energy efficiency throughout most of the agencies of the Federal Government that is quite independent of anything that appears in the National Energy Strategy. That is not the only activity in the administration's program.

Mr. WOLPE. Okay. The last question I have is on a different topic, which is related to the recent Environmental Protection Agency draft report, "Evaluation and the Potential Carcinogenicity of Electromagnetic Fields." I know you are familiar with that.

You know the—it was reported—I would be interested in your role in the process by which the report was initially delayed and then subsequently released. It was originally scheduled for release on November 27, 1990. It was finally released December 14th. My understanding is that you had met with Mr. McCoy, the—Mr. McGowey—I'm not sure if I'm pronouncing it—

Dr. BROMLEY. McCoy.

Mr. WOLPE. McCoy—the EPA's project manager, November 26. Could you indicate sort of what your views were and what you expressed to him at that meeting and why the delay that you apparently had recommended?

The other question I have relates to the report that appeared in the Associated Press indicating that you had proposed a certain

number of people to undertake a review of this work, that the EPA Scientific Advisory Board did not select any of the people proposed because they were not considered objective in that they were people who had basically taken a public position that these electromagnetic fields posed no health risks. Could you just give us your views on that?

Dr. BROMLEY. Absolutely. First of all, I want to correct that last statement from the AP. The list of people that I provided to Administrator Reilly was provided in response to his specific request that I get him a list of people who I felt would have the scientific background to really undertake a look at the fundamental physics, chemistry and biology of the effect, and so this was not as the statement suggested an uninvited effort on my part to stack their committee. This was a response to a very specific request from Administrator Reilly. The fact that they were not selected is out of my hands, of course.

Mr. WOLPE. Is the statement accurate contained in that news report that these were all people who had in fact taken a public position that the fields pose no health risks?

Dr. BROMLEY. I do not know what, sir, the position was of all of the people. I do know that one of the people on that list, who is an old friend of mine, has taken an extremely negative view of the work. I respect his view. He has been for many years the chairman of the Physics Section of the National Academy of Sciences. He is a very distinguished physicist. And when he spends time looking into a matter I tend to take what he has to say rather seriously. But the rest of the folk involved there were people who, in response to Administrator Reilly's request, I got as suggestions from people throughout the community whom I respect, who said, these are people who have looked at this problem. And I did not know what their response was, but on the basis of my investigation they were people whose views I would respect however they come out on the subject.

Mr. WOLPE. Is it normal procedure for the Federal Coordinating Council for Science, Engineering and Technology to subject such draft reports to review?

Dr. BROMLEY. In this particular case the meeting that you referred to earlier that was held came as a result of a discussion that Administrator Reilly and I had had in which he asked me if I would like to be briefed on this report. I said that I would. Four gentlemen from EPA came to my office, spent about 2 hours discussing with me the report. And I want to emphasize that we did nothing whatsoever to change the report, not a word of their report, not a word of the Executive Summary was changed.

I must say that I did react to a view graph which was used in the presentation made to me which I felt went far beyond the report or the Executive Summary in reporting a causal link between exposure to low frequency/low intensity electromagnetic fields and childhood cancers. And it was simply the question as to whether the briefing I had received was, in fact, consistent with their report. I merely asked the question, and Eric Bretauer, who is the chief scientist at EPA, subsequently decided that it would be a good thing to add a note as a Foreword or Preface to the report.

But the report was not delayed and nothing was changed in it. It was simply a question as to whether the statement that came out was, in fact, consistent with the material in the report, and that was asked on a purely scientific basis within my function as science adviser.

Mr. WOLPE. Has the release of the more recent report of the Electric Power Research Institute, which raises concerns and which I think took some people by surprise because of its industry sponsorship, caused you to alter your own views or perspective on this in any respect?

Dr. BROMLEY. I do not have specific views on this, sir, because this is not a field in which I, myself, have worked at all. I do not propose to have any special knowledge of this. All I can ask is that people, in my view, should be consistent that the report, its Executive Summary and the public statement concerning that report should be scientifically consistent, and that is what I asked.

Mr. WOLPE. Okay. Thank you very much.

Mr. Rohrabacher?

Mr. ROHRABACHER. Dr. Bromley, I am from Southern California as is our distinguished chairman who now is about to retake his seat, and in our area the aerospace industry is of vital importance to our economy as well as the aerospace industry is of vital importance to our economy as a nation. There is a research project in the budget that some of us believe is vital to keeping America's aerospace industry number one in the world, not just in the years ahead but in the next century, and that is the National Aerospace Plane project.

Dr. Bromley, do you support building and flying of the X-30 research aircraft?

Dr. BROMLEY. If I may, sir, let me back off just a little before addressing your specific question.

Mr. ROHRABACHER. As long as in the end you give me a yes or no, I will be very happy. You can back off as far as you want.

Dr. BROMLEY. I have been asked to serve on the steering group for the National Aerospace Plane and have done so since I have been here, and I have been extremely impressed by several things about the program in the last year. First of all, they have made dramatic progress in the development of new materials. Secondly, they have made equally dramatic progress in computational aerodynamics, developing algorithms to understand the behavior of structures of hypersonic flight, and perhaps even more important than any of those is the fact that the five industrial concerns that previously were on a more or less competitive basis in the program have decided to join together into a team, and it is a singularly powerful team. And I think that that in itself is a very important development out of this activity.

Now, as to whether we move forward to the X-30 as an experimental flight vehicle I think depends on the evaluation that will take place at the conclusion of Phase II. Phase III is the one in which we would propose to go forward with the experimental flight vehicle. And from everything I know about the program at this point I would have to say that I think that the group is in excellent shape to meet the criteria established for the completion of Phase

II, and on the basis of everything I know about the project I would certainly be in favor of proceeding to Phase III.

Mr. ROHRABACHER. Thank you very much. Have you heard of any information about any contracts being made with the Japanese by American companies to build a hypersonic craft that would be similar to the X-30?

Dr. BROMLEY. I have heard no statement that I would take as having any degree of reliability at all.

Mr. ROHRABACHER. There was just something said about that today and I am very interested to see if there is any validity to that.

Doctor, are you worried at all about American technology that was developed as part of our military buildup perhaps in the last 10 years being sold to the Japanese and being used to create an aerospace industrial base that would be then used to compete against us?

Dr. BROMLEY. I am concerned, sir. I think it is very important for us to keep in mind that there are, in fact, only three industrial sectors in our country that have managed to maintain sound, solid, positive balance of payment records: one is the pharmaceutical industry, one is the chemical industry—both of those achieved that result because they have been very effective in achieving protection of their intellectual property; the third is the aerospace industry. There I think is definitely a case where our continued international leadership has resulted from a synergism between our military needs and our civilian developments, and I am concerned that we not lose that leadership position we have now.

Mr. ROHRABACHER. To be more specific, Doctor, I have been on this committee. We have talked about the FSX fighter, which has been, of course, meaning we are selling them technology developed by billions of dollars worth of American research from the military. I understand the Patriot missile system, now they can manufacture the Patriot missile system, again developed with billions of dollars worth research in defense.

Should we be selling our weapons technology, or should we be demanding that these people just buy the finished product?

Dr. BROMLEY. That is a very difficult question. I think that my own feeling is that the time probably is past when, except in very exceptional cases of very specialized technologies, that we can prevent other countries from getting them either above the table or under the table. And so my approach to this is to try to ensure that in the process we get something of equal value for the U.S. And I think that we have to be much more aggressive in our negotiations than we have been in the past. We have to do our homework more than we have done in the past to understand and know what the other side in the negotiation has available that would be of use to us. And in a great majority of our negotiations I would look for a more reciprocal benefit, and on a few select technologies that are critical to our activities I would be much more protective even than we are now.

Mr. ROHRABACHER. Thank you very much, Doctor. Thank you, Mr. Chairman.

The CHAIRMAN. Thank you very much, Mr. Rohrabacher. Mr. Hall?

Mr. HALL. Thank you, Mr. Chairman. Dr. Bromley, on my first question I will try not to be hurtful and in my second question I will try to be helpful. I want to beat around on Landsat a little more with you there, and I have been out. You know, we had to vote and I really do not know what your answers have been, and you might stop me if I got into something that you feel you have completely covered.

But the Interagency Committee, as you know, has written a report on the value of the Landsat data for global change research, and I guess, first, when will this report be made available for Congress? Is that in the record?

Dr. BROMLEY. If I may, sir, I believe the document to which you refer is currently simply a working paper in one of the subgroups of the Committee on Earth and Environmental Sciences, and before it could ever become a report it would have to come from that working group to the committee and then from that to the full Federal Coordinating Council for approval along the way. I have not seen the report yet. It is still at a very early level, so I am afraid, sir, that I can not give you a firm date.

Mr. HALL. But you agree with us that Landsat is essential to global change?

Dr. BROMLEY. Landsat, and following it EOS, are of great importance to a coherent program of global change research, I would agree, sir. And to many other things, indeed.

Mr. HALL. Will you supply that for us for the record when it is available to you?

Dr. BROMLEY. When the report is issued?

Mr. HALL. Yes.

Dr. BROMLEY. Of course.

Mr. HALL. How does the administration plan to implement the President's commitment and share the continuity of the Landsat-type data in the years ahead? What are his plans, do you know?

Dr. BROMLEY. At the moment, as you will note, in the 1992 budget we have provided a request for 17 million within the Department of Commerce to support the operation of Landsats IV and V through August of 1992 when we expect Landsat VI to become operational. Now, in the case of Landsat VI, the launch will be the responsibility and the subsequent treatment of the data from Landsat VI will be the responsibility of the Earth Observing Satellite Company, a new entity, and that is the state of planning at the moment, sir.

Mr. HALL. I am not suggesting and I have only heard it said, and I can not even tell you who said what, but that NASA has not been particularly helpful in the Landsat Program. Do you want to comment on that and on keeping it going as we need it to go for continuity?

Dr. BROMLEY. I do not have any information on that, sir.

Mr. HALL. Do you have any feelings about it?

Dr. BROMLEY. I personally think that Landsat has been an overwhelming success, that it is still of, really, substantial value, and I look forward to its successor, the Earth Observing System—EOS—as a vitally important part of our overall global change program and it is providing data that will be extraordinarily valuable in fields like agriculture, earth resource management, and so on.

Mr. HALL. And my helpful question. I have never been misquoted but I have said a few things I wish I had not said, and I know that you make so many speeches and have—you are very creative, you write a lot, and you are listened to respected. You are good press. I want to—

Dr. BROMLEY. I hate to think what is coming, Congressman.

Mr. HALL. No, I said helpful. I really am sincere because Congressman Boehlert asked you some questions about the supercollider, and I did not hear all of those but I always try to help him understand it better. And this is as much for his benefit, really, as it is for mine and yours.

But, on the Science in Government report that came out January 15th, this year, not too long ago, they made some inquiries of you and you spoke of priorities and who would make the priority decisions. You spoke of the obvious difficulties of the constant dollar—I can not read all that. But I read the question and answer series there and I am sure you remember it.

I want to give you some more ammunition to feed back with them. The problems with little science or big science and the damage that the supercollider might do to little science, please note, and I know you know, that only 1-1/2 percent of the Federal budget for general science, space and technology for 1990 went to the supercollider, only 1-1/2 percent for 1991 is projected, and less than 3 percent for 1992. And, with my suggestion that that is not damaging to little science, but supportive, and that all should work in together. And, even on through 1994 just slightly over 3 percent of the total budget for science, space and technology.

I think you know—you remember one time before you testified before our committee, it seems like when Congressman Lujan was here, and some answer was given that was misunderstood, and you came back and I think cleared the record very well. And I notice you have Ms. Bach with you, and that is comforting to a lot of us to know that you have her as your back-up.

Dr. BROMLEY. Comforting to me, too.

Mr. HALL. I guess the question I have is, just to take these actual factual figures here, is to what percent of the budget is extracted and the minimum damage that is done to small science by pursuing this that I understand you have detailed here before this committee today as a major hope and aspiration of this country in the field of science?

That is my helpful question.

Mr. BOEHLERT. Dr. Bromley, let me ask before you answer if I just may have you yield for one second for a friendly inquiry.

Mr. HALL. I am not sure if I—I want to hear the question before I yield.

[Laughter.]

Mr. BOEHLERT. It is a friendly inquiry.

Mr. HALL. Sure I will yield.

Mr. BOEHLERT. Does that mean, in view of your question, I take it, you are in the undecided column?

Mr. HALL. No. I really wanted it to go up between New York and Canada. But when we lost that deal, why—

No. I appreciate your good work, Doctor, and the answers you have given. And I particularly want to say again that I appreciate

you coming, having the courage and the professionalism to come back to this committee and clear up something that I think you were misquoted on, and certainly misunderstood on. Because I believe you support President Reagan and President Bush in the building, construction and finding this greatest research tool in the history of man. I am a little disappointed it did not get over in District 4. But, if you straighten it out instead of making it a circle, it would wind up in my district.

[Laughter.]

Mr. HALL. I yield back my time, Mr. Chairman.

Dr. BROMLEY. You sound like, sir, you are making it into a linear collider.

Mr. HALL. That is right. A one-time collision.

[Laughter.]

The CHAIRMAN. Why, I have to point out that the discovery of the quark was made on a linear collider and earned a Nobel Prize. So maybe if we turn this one into a linear collider it would not hurt too much.

Mr. Geren?

Mr. GEREN. Thank you, Mr. Chairman. Just to follow up on Congressman Hall's comments or question or whatever it was on the big science/little science. You know, much of the criticism of the supercollider has been directed—well, is based on the fact that it is big science and it does hurt little science. But when you break the supercollider down into all the different people and entities that are working on it it seems to me that it is really a collection—it brings a lot of little science together under one umbrella, and I would like you to address that and try to clear up that. It seems that is a criticism that is thrown at it without really looking at the real facts.

Dr. BROMLEY. Your point is very well taken that the discussion of big science and little science tends to contribute very little to much of anything. It is very important to recognize that with many of the major facilities, accelerators, telescopes, national light sources, all of these things, once you have got them built, the people that actually use them are individual faculty members with a post-doc and a couple of graduate students, so that is not distinguishable in terms of what they are doing from what goes on in a basement laboratory in some university building.

There is no sharp distinction between small science and big science. There is one distinction and that is that we have always up until recently felt that discoveries, that fundamental discoveries emanated from a single brain, and the thing that is different is that we have finally recognized that in some fields, and particle physics is one of those, it is no longer possible for any human to really work alone on the frontier. You need the combined collective efforts of experts in a number of fields working together and jointly you make the discovery. And so there is a difference in that sense, but I really would have to completely agree with you that there is a huge gray area that people do not understand between big science and little science, and the fact is that at most of the big facilities people are doing little science.

Mr. GEREN. Thank you. I have one other question. I would like you to—this is something of a big picture question as well. Recent-

ly, the Director of the Brookhaven National Laboratory wrote in the Atlantic Monthly, said that national labs are—and I am going to quote—"threatened by a tendency to manage Federal undertakings of all kinds including scientific projects as though they were businesses constrained by business procedures and requirements and responsive to business incentives and pressures. The attempt to treat basic research as a business has slowly changed the structure and spirit of the national laboratories and begun to strip away the special protection this country once accorded them and to taint the fragile atmosphere needed for them to thrive."

In the same article the Director described the massive amounts of paperwork and regulations prescribed by the Federal Government and the diversion because of that of an increasing amount of resources away from the research towards satisfying these bureaucratic requirements.

Would you just comment on Dr. Samios'—

Dr. BROMLEY. Well, I understand completely where Dr. Samios is coming from, but I would say first of all that no one in the scientific community has any reason or right to object to accountability. I think that the taxpayer, as I said at the opening of my statement, has been extraordinarily generous to science and technology in this country, and I felt that, perhaps, Dr. Samios might be misunderstood. I am sure he agrees with me that accountability is not the question. We all agree that that is very important.

There is a fundamental problem, and that is that we occasionally mix the procedures that we are using in the supportive research. I have emphasized and it has been emphasized back since 1946 that research and development support is most effective when it is viewed as an investment. But increasingly, there is a tendency to treat it as a procurement, and the documentation that is required to allow the Brookhaven National Laboratory to do a particular piece of research frequently resembles the kind of documentation that would be required in the purchase of a battleship, and that confusion between procurement and investment is a confusion that I think serves all of research and development badly. I think that that really is at the heart of Dr. Samios' concerns in that article.

Mr. GEREN. I agree with that assessment. I feel that—not looking, I had not thought of it comparing investment and procurement, but trying to apply procurement standards to scientific research perhaps makes the public and the Congress more impatient than it should be and looking for something that really is not there.

Dr. Bromley, thank you for your comments and your testimony today. Mr. Chairman, I have no further questions.

The CHAIRMAN. The Chair would like to ask a couple of questions. Probably more, but I recognize the time constraints and I am trying to get through by four o'clock, Dr. Bromley.

Dr. Bromley, we had in addition to the high praise for the overall budget some—for R&D—some comments that some areas were out of balance compared with other areas. For example, the Superconducting Supercollider, according to Mr. Boehlert, probably is getting too much money, and I think it was Mr. Swett indicated that there probably was not enough money going into things like the Advanced Technology Program.

Assuming that there would be some justification for altering these priorities, how do we do it in the congressional process where the Superconducting Supercollider is funded in one Appropriations Subcommittee and the Advanced Technology Program is funded in another? I am getting to the point of, is the Congress prepared to do a priority-setting job effectively on this broad-ranging kind of a budget, or have you thought about how that could be handled more effectively?

Dr. BROMLEY. Well, I would first of all have to say, Mr. Chairman, that you are vastly wiser on this matter than I am. But the question you raise is one that does concern me and my people very much because we find that, for example, when we bring forward the NSF and the NASA budgets, and Senator Mikulski, who is very sympathetic to this but has also under her wing Veterans Affairs and Housing and Urban Development, and in the most oversimplified fashion Veterans Affairs with pensions and other entitlements represents the past, Housing and Urban Development has a great constituency for the present, and NSF and NASA are hopes for the future, and it is extraordinarily difficult, and I understand the difficulty, under the very real political pressures to arrive at the appropriate priority decisions that are in the long run best interests of the nation.

I have often felt, as I am sure you have, that if we were starting over again from scratch we might think of a more appropriate realignment of responsibilities. But that, sir, is out of my realm of action entirely.

The CHAIRMAN. Well, I understand that. You, perhaps, would not even want, if you could, to intervene in the arcane processes of the Congress. But this is really our problem when it comes to priority-setting. Assuming that we were agreed in the Congress that you have presented overall the best possible R&D budget but it needs some slight modification in priorities within it, we do not have the capability to do that. We have to measure the R&D budget and its components against non-R&D things, as you have so well pointed out.

And it is even worse than that. The caps that we are living under apply to domestic discretionary and military spending. We can not make trade-offs between military R&D and domestic R&D, and I am deeply concerned about that. I am going to apply these great talents that you attribute to me to try in coming up with a solution, but I am not sure that I will be able to come up with a satisfactory answer.

One additional question that deals with a subject I have fretted over for many, many years, and it was—it comes up in connection with the Landsat-EOS situation. Part of our problem with Landsat has stemmed from the fact that we have a very valuable system here which, in effect, overlaps a classified military system and it has caused some policy problems over the years.

The question that I intend to raise during the course of this session of Congress, and it is not new, I have raised it before, and I would just ask you to comment on it, is do you think there may be in these changing times the possibility that we could have an internal review of the degree to which we might be able to have some

constructive interaction between the open and the classified systems?

Dr. BROMLEY. I could not agree more, Mr. Chairman. I think that the time is long overdue for a very careful examination of that because my own personal prejudice is that we could, perhaps, all benefit from the availability of some of the material that has not in the past been available to broad public purposes.

The CHAIRMAN. Well, I will probably take that up with you sometime in the future, and it is been my hope I could get some of my colleagues in the Intelligence and Armed Services Committee to join with me in asking for an internal review of this matter to see if we could not come up with a somewhat better solution.

Now, for the remaining few minutes we will have a second round. Mr. Kopetski, you did not get in on the first round, did you?

Mr. KOPETSKI. Thank you, Mr. Chair, but—

The CHAIRMAN. I would be glad to recognize you.

Mr. KOPETSKI. Well, I appreciate that very much, but I think I will defer to the other members today.

The CHAIRMAN. All right. In that case, do you gentlemen, either—Mr. Hall has one more pithy remark.

Mr. HALL. Yes. And helpful. Another helpful.

[Laughter.]

Mr. HALL. And this is on behalf of Mr. McCurdy too. You did mention international competitiveness, and, of course, very adequately. But it has been pointed out that remote-sensing, I guess like Landsat, has played a very crucial role in the Iraq war up to this time—at least to McCurdy, who was over there and spent a couple or three weeks with the troops. Not as a Congressman but as a—I don't know if he is a lieutenant or general or private or what he was, but he wore the uniform and he was there and observed the war as it was unfolding.

There is some concern that the White House might not really stand behind the whole remote-sensing industry and abandon it to the French SPOT system. I guess when we talk about international competitiveness it just seems to me that we ought to make some type of a firm commitment to a continuing series of Landsats, beginning with Landsat VII, and why wouldn't we? Am I reading the President wrong on that?

Dr. BROMLEY. I think, if I may, sir, that you are. Because I do not know about—quite frankly, do not know the details of planning having to do with Landsat VII, but I do know that the President is very strongly committed to the, for example, the EOS series of instruments that will give us unprecedented views of all the Earth's surface and allow us, because those measurements are being made for the first time simultaneously, so that we do not have to correct for change in cloud structure and changes in the atmospheric column and so on—will allow us do to analyses on these new data that will be vastly more informative than the ones coming out of Landsat.

So it is not that we are giving up on remote-sensing. I think we are moving into an entirely new generation of remote-sensing where we can do things that were quite impossible before.

Mr. HALL. Well, discuss the French SPOT system, if you would, just a moment. Compare it to our thrust, if you can.

Dr. BROMLEY. I am afraid there, sir, that you are asking me to give you details that I do not have readily at hand. I have difficulty keeping track of our own systems and the French ones are a little out of my realm at the moment.

Mr. HALL. But I would not want to let ours atrophy away and rely on theirs because we have found them fighting to the last American too many times. I do not want to rely on any French technology is what I am saying.

Dr. BROMLEY. Without commenting on some aspects of the statement, sir, I agree with you that it is important for us to maintain our domestic strength in this area.

Mr. HALL. I will not have any more questions because Mr. Wolpe has left and I can not leave untill Mr. Boehlert leaves, so I will be here with the chairman untill the end.

[Laughter.]

The CHAIRMAN. Well, just to clarify this Landsat situation, the value of the Landsat continuity of data stems from extremely sophisticated multi-spectral scanning data. The French SPOT does not provide that. It provides at the moment three spectral bands, as I recall. It does have the advantage of having a 10-meter resolution compared to the 30-meter resolution. But for most purposes that is not really a huge difference.

The question about EOS is whether it will continue to fly an instrument that will provide the multi-spectral data that has been accumulated now for a generation, and we certainly trust that it will do that, and, in fact, represent improvements over that data, as you have already indicated.

Dr. BROMLEY. I would certainly support that, sir, because the importance of horizontal data banks over long periods of time can not be overemphasized.

The CHAIRMAN. Correct. Mr. Boehlert, you want to say something that will attract Mr. Hall's attention?

Mr. BOEHLERT. I certainly do, Mr. Chairman. I think, Dr. Bromley, you have plowed some—

The CHAIRMAN. This is what we call peer review.

[Laughter.]

Mr. BOEHLERT. I think, Dr. Bromley, you have plowed some new ground here today, and I want to revisit something you said. This is about the first time that we have heard that the foreign contributors would come only after construction was well under way. Because with other big science projects, and the Space Station is the best example, the argument has always been that the international partners would only come aboard if they could have some say in the planning and design. So which is it?

Dr. BROMLEY. Well, I think that they really are different situations, sir, because in the Space Station, for example, we have had agreements with the Canadians and the Germans and the Japanese and they have been involved from the very beginning of the project. The SSC, however, has been a uniquely American development. It was the local high energy physics community that developed the constituency that brought that forward, that convinced President Reagan to support, and convinced President Bush to support, and the foreign—for example, you know that in Europe there is a quite different constituency that would very much like to see a

smaller but still very large machine built at CERN, the large Hadron collider. And there is some competition, in fact, for whether the Japanese would buy into one or the other.

The foreign countries with—India is the one exception that has already pledged flat down $50 million toward SSC. But with the other countries we are still discussing it and negotiating, and then they are behaving very much the way we do. When we are asked to join into activities of a scientific nature in other countries we wait until we see that those other countries are actively proceeding.

There was a very specific case in point. The Canadians have been very anxious to have us participate in a very significant way in the development of what is a frontier instrument, the Kaon Factory in Vancouver. It will be unique in the world on the high intensity frontier rather than the high energy frontier. And we have simply been waiting until the Canadians really get fully into the Kaon project before we commit our funds.

Mr. BOEHLERT. Do you think we are fully into the SSC project?

Dr. BROMLEY. No.

Mr. BOEHLERT. I recall a colloquy we had last year. I asked you if there would be a point where you would say as Science Adviser to the President this is far enough, the cost is now at the point where we really can not justify it, and you said, yes, there would come a point where you might be willing to say that. If I recall correctly, the initial estimates were $4.4 billion and then they have gone up incrementally and now the official released report is $8.2 billion. Are you familiar with the report of the independent cost-estimating staff within the Department of Energy, and do you recall the figure that they had, their estimate?

Dr. BROMLEY. If my memory serves me, it is slightly over $11 billion.

Mr. BOEHLERT. Over $11 billion, and we still have not dug the first spadeful of earth—turned the first spadeful of earth over.

Dr. BROMLEY. That is correct.

Mr. BOEHLERT. And, if I recall, the independent cost estimate, we refer to it as ICE, we all use acronyms, and theirs was a chilling report. They said they were being conservative in their estimates.

Dr. BROMLEY. Yes.

Mr. BOEHLERT. And so it is conceivable then, Dr. Bromley, that we could be talking about a project and $14-$15 billion. That is conceivable, not beyond the realm of possible.

Dr. BROMLEY. Let me only say that I would be very surprised if anyone came forward with any such estimates. Because in this case the Department of Energy under Admiral Watkins' direction has really tried to get a hold on what the real costs are, and more than this they have removed the whole construction responsibility from a bunch of scientists. And, as one of those scientists, I know only too well that we have a horrible tendency to think of bright new ideas as we go along with the project, and it is sort of like talking to your architect when you build your house. It is wise not to make changes during the course of the project because the costs go up very rapidly.

This time there has been a firm prohibition that once the design is frozen and accepted that is it.

Mr. BOEHLERT. Well, of course, Admiral Watkins is the very Cabinet officer that said we would not build it if it went a penny over $5.9 billion, and I would suggest it is many, many, many pennies over that now and the end is not yet in sight.

Just one last thing for the record, Mr. Chairman. When I asked about he funding for the Advanced Technology Program you responded that the administration request is in the magnitude of $3.6 million.

Dr. BROMLEY. No. We've asked for 36 million, sir. Rather ten times 3.6 .

Mr. BOEHLERT. Well, 3.6 times. You asked last year 10 million.

Dr. BROMLEY. Yes.

Mr. BOEHLERT. But I do want to point out for the record that Congress last year approved $36 million. So your request this year essentially is for a static funding over what Congress approved last year. And I just point that out, Dr. Bromley. I am not trying to be in an adversarial position because I know you share some of the questions I have about the Superconducting Supercollider.

But it is a very difficult time, and as you pointed out in your testimony there are scarce resources. It is a very good science budget overall, but there are some problem areas. And when we have a 120 percent increase in one of those areas where the end is not yet in sight in terms of the projected cost I have a legitimate concern.

Thank you very much, sir.

Dr. BROMLEY. Thank you.

The CHAIRMAN. Mr. Hall would like a brief rebuttal.

Mr. HALL. Mr. Chairman, just in an effort to be helpful again, I would like to see these things in the record if Dr. Bromley agrees with them.

I think your statement on your no-topics-barred interview of January the 8th, your answer was that the Japanese simply said they wanted more concrete evidence that we were moving forward aggressively, and I do not think that is asking too much. Just exactly what they meant by that, I am not sure. But I think if I were representing them I would expect the same thing.

And I think we are seeing some concrete evidence. It is slow but it seems to be sure. The Congress has supported it, the last two Presidents have supported it, and the budgets, the estimates that we really have from the lab are $7.8 billion. That figure has not changed, has it?

The DOE has $8.2 billion and three other independent cost estimates were $8.4 billion, $8.6 billion, and the one that I do not like to use is $11.2 billion.

Dr. BROMLEY. If I may, Mr. Chairman, let me simply emphasize that there is a very clear reason for these changes in the numbers in that they are apples and oranges in the sense that some include much more in the way of detectors than do others, some include much more in the way of contingency than do others, some consider a significantly longer construction period than do others.

Mr. HALL. And it is not terribly unusual to have overruns and underestimates on anything of this size.

Had not we spent about a billion dollars on the Space Station before we ever had an international agreement signed?

Dr. BROMLEY. Before the agreement signed?

Mr. HALL. Yes, even before it was signed.

Dr. BROMLEY. I think that is probably true. Yes.

Mr. HALL. I thank you. Yield back my time, Mr. Chairman.

The CHAIRMAN. Thank you very much, Mr. Hall. And, Dr. Bromley, I want to express my very great appreciation to you. You have spent more than 2-1/2 hours and you have been called upon to respond in detail to a number of specific questions which really are not directly within the domain of your office, but which you have handled extremely well. And we appreciate that very much and we look forward to continued cooperation with you.

Dr. BROMLEY. Thank you, Mr. Chairman.

The CHAIRMAN. The committee will be adjourned.

[Whereupon, at 4:00 p.m., the committee was adjourned, to reconvene subject to the call of the Chair.]

APPENDIX

QUESTIONS AND ANSWERS SUBMITTED FOR THE RECORD

1. What has been OSTP's involvement in assessing the results of the Report on the Advisory Committee on the Future of the U.S. Space Program? Do you plan on making any recommendations of your own as a member of the National Space Council?

As you know, NASA has undertaken a conceptual redesign of the Space Station in response to a recommendation from the Augustine Committee and Congressional mandate. My staff and I have participated actively in the Space Council's consideration of the conceptual redesign with particular focus on the scientific and technological aspects of the planned utilization of the Space Station.

2. The Augustine Committee identified once again the need for a broad and stable consensus on what we should be doing in space and how much we should spend on these activities. Such a consensus must involve the Administration, Congress and, most importantly, a well-informed public. What role will you play in developing a durable consensus on a long-term budget for NASA?

I think that the Space Council should have the lead role in developing such a consensus, but I shall continue to play an active role within the Space Council.

3. The Augustine Committee noted the value of international cooperation for space activities, but recommended being more careful about entering into cooperative ventures. The committee also recommended that such cooperative ventures not include "in-line critical program elements." What guidelines would you recommend for evaluating potential cooperative space activities?

I agree with the Augustine Committee that international cooperative ventures should be entered into carefully, and that this is especially the case when "in-line critical program elements" are involved. However, to preclude all such critical elements from international cooperation is unduly restrictive.

4. One of President Bush's stated goals is to "make America number one in math and science." Please elaborate on how we can make that happen, and how that achievement can be measured.

The goal cited in the Question is one of six developed by the President and the Nation's Governors at the Education Summit held in Charlottesville, Virginia in September 1989. It focuses the nation's attention on the need to improve the performance of U.S. students in math and science. No one actor can achieve this goal; it requires the combined efforts of Federal, state and local governments, the higher education community, local school districts, professional organizations, teachers, administrators, and the science and engineering community. And, as I have stated in public addresses across the nation, parents must be called upon to play a central role in this process.

The President's FY 1992 Budget Initiative for math and science education is one of the major Federal responses to this goal. The Federal Coordinating Council for Science, Engineering, and Technology (FCCSET) assisted the President in the development of this initiative. The FCCSET effort was conducted under my direction through the Committee on Education and Human Resources (CEHR). Leadership for the Committee is provided by its Chairman, Admiral James D. Watkins, Secretary of Energy, and Co-Vice Chairmen, Dr. Ted Sanders, Under Secretary of Education, and Dr. Luther S. Williams, Assistant Director for Education and Human Resources for the National Science Foundation. The full Committee is comprised of 16 Federal agencies that, combined, have major responsibility for education and human resource development programs and control significant resources such as Federal laboratories and science and engineering talent that can be used in support of education improvement. Included are the National Science Foundation and Department of Education, as well as mission agencies such as the Department of Energy, NASA, and the Department of Health and Human Services, with significant education activities of their own. FCCSET CEHR provides a mechanism for building broad-based expertise across Federal agencies, for coordinating long-range planning and more effective use of Federal resources, and for catalyzing innovative approaches to meeting education needs.

In its first year of activity, CEHR established a Federal plan for math, science, engineering, and technology education, produced the first comprehensive inventory and budget for existing Federal programs, and defined criteria against which a comprehensive Federal plan and individual agency programs could be evaluated. The Federal strategy for improving mathematics, science, and technology education includes both formal and informal education programs and spans all education levels—precollege to graduate school. Program emphasis in the President's FY 1992 budget is placed at the precollege level in order to facilitate achieving the immediate objective of improving math and science performance by decade end. The intent of the strategy is to catalyze and assist in a general rebuilding of the education system starting at the bottom. Its strategic objectives are, in descending order

of priority: Improved science and math performance; a strong precollege teacher work force; ensuring an adequate pipeline for the science and technology work force, including increased participation of under represented groups; and, improved public science literacy. The implementation strategy needed to meet these objectives varies by education level, its programs include teacher enhancement and preparation; curriculum reform; organization and operational reform awareness and science literacy. A copy of the report, By the Year 2000: First in the World, describing FCCSET CEHR efforts has been given to the Committee.

Measurement of achievement in math and science is integral to the National Education Goals. The Federal sector has several major efforts underway. The Department of Education's National Assessment of Education Progress (NAEP) will continue to measure student competency in math and science. Both the Department of Education and the National Science Foundation are involved in sponsoring projects on international comparisons of educational achievement. At the National Science Foundation, two major assessment/measurement efforts are underway: First, a framework is being developed for the new biennial report series on the condition of math, science, and engineering education from kindergarten through undergraduate levels; and second, NSF has undertaken a new initiative to strengthen and broaden approaches for diagnosing instructional needs and tracking student progress.

This endeavor calls for broad public involvement and is not solely a Federal responsibility. The National Governors' Association, for example, has set up the National Education Goals Panel, comprised of both Governors, Administration officials, and Congressional Leadership, which will report annually on progress in meeting the National Education Goals. At the National Academy of Sciences, the Mathematical Sciences Education Board is addressing these issues for mathematics, and the Board for International Comparative Studies in Education is working on the challenging problems involved in comparisons of educational achievement between the United States and other countries. There also exist many community-based organizations, business/industry activities, and volunteer programs that are contributing to the efforts to achieve progress in mathematics and science education.

The National Education Goals are very challenging and require a concerted effort by all that have a stake in educating our youth. Americans are frequently stirred by challenges to make great exertions in achieving difficult goals. If there is that kind of response to the challenge to improve math and science achievement, we should make considerable progress in attaining the National Education Goals.

5. We hear conflicting reports from the media as to the health of the scientific community; in your opinion, what criteria should be used to assess the health of science in the U.S.?

Numerous metrics are often used to describe the health of the U.S. science community, including funding levels, number of grants, number of scientists supported, the percentage of GNP devoted to these activities, the social benefits or rate of return to investments in research, publications and citations, patents, and Nobel and other major research prizes. Each of these captures only one small aspect of the functioning of the science enterprise. A more general measure is the extent to which our science enterprise contributes to advancing the frontiers of knowledge, meeting national needs in areas ranging from economic competitiveness to national security, educating our youth, and improving our quality of life. I remain convinced that overall we still have the strongest science and technology enterprise in history. It is, however, true that other nations, by focusing their efforts, have moved up to equal us in some areas -- or in a few cases to surpass us. This is neither surprising nor necessarily bad. But it is essential that in those areas where we may not define the current frontiers, we remain close enough that we can exploit new discoveries or developments, wherever they are made, rapidly and effectively.

6. Despite increasing budgets for federally-funded research, the demand for grants continues to increase. How do you think that the science community can more realistically prioritize its funding requests?

Peer review remains, far and away, the best method of evaluating priorities among projects in fundamental science research. Peer review is the traditional means of deciding whether or not to fund individual research grants as well as the large specialized facility projects that are required for forefront research in many areas. It more than anything else is responsible for the present strength of our enterprise; where there are problems with peer review they are relatively minor and can be fixed. At the same time, a key challenge for the scientific community in the coming years will be to continue to improve coordination and planning across disciplines so as to make the best use of available resources.

7. The High Performance Computing initiative includes creation of a National Research and Education Network (NREN). How will the views and concerns of the non-federal user community for the NREN be included in the planning process for the network, since FCCSET membership is limited to federal agencies?

Most users of NREN will be researchers and educators on academic and industrial campuses, so their concerns are of paramount importance and are being considered both formally and informally. In fact, a private sector advisory committee is being formed for this purpose by the Federal Networking Council, an interagency group concerned with management of NREN. In addition, a Network Users' Group, primarily composed of persons from outside the Government, will be part of the NREN governance structure. Finally, we also have a panel within the President's Council of Advisors on Science and Technology (PCAST) that provides an overview of our High Performance and Communications programs.

8. Do you think that a full multi-year program funding approach adopted last year by the Congress for CRAF/Cassini and the House for Superconducting Super Collider can be available for other large projects such as the GEOS weather satellites, National Weather Service modernization, and Space Station Freedom?

Last year the Congress gave multi-year <u>authorization</u> for CRAF/Cassini and the House of Representatives for the SSC after rebuffing similar requests for the Space Station in the previous two years. Any attempts that Congress makes to promote longer term stability in funding for R&D are, of course, appreciated. The effectiveness of these efforts will be enhanced if multi-year authorizations can be translated into multi-year appropriations. The Administration is most interested in exploring how better to provide the stable funding required for long-term projects such as the ones mentioned above.

9. What is the status of United States participation in ITER, the international program to build a large-scale fusion reactor?

A team led by DOE currently is negotiating terms for U.S. participation with our prospective foreign partners in the Engineering Design Activities (EDA) phase of the ITER project. The U.S. is proposing to locate the central EDA offices at a site in San Diego. It is hoped that the negotiations will be completed, and agreement reached, within the next few months. We view ITER thus far as a very effective and successful international cooperation involving Japan, the USSR, the EC and the U.S.

10. While the intramural research programs of the National Institute of Standards and Technology have been given a long overdue increase, the extramural programs designed to help industry strengthen its technological base are either frozen or eliminated. What do you see the role of NIST in fostering industrial competitiveness?

The Administration has proposed a 15 percent increase, to a total of $248 million, to expand the National Institute of Standards and Technology's (NIST's) ability to perform generic applied research and technology development to address a rapidly growing number of important standards and measurement issues. The increase will allow NIST to conduct research and provide laboratory support for manufacturing technologies, information technologies, and other emerging technologies that are extremely important to the U.S. economy. In addition, the budget includes $36 million for the Advanced Technology Program (ATP) to help fund industry-led high-risk R&D on precompetitive technologies. I have been very impressed by the first round of awards under the ATP program.

11. The Advanced Technology Program is due for an increase from $10 million to $37.9 [$35.9] million this year. What are the priorities for how that increase will be allocated?

Approximately $11M of the FY91 funds will be used to fund the second year of projects initiated with FY90 funding. NIST will announce a second open competition and use the remainder of funds for new project starts resulting from the second competition. As was done in the first competition, the Request for Proposal (RFP) will cite the criteria below:

- **Technical and scientific merit (20%);**
- **Broad-based commercial benefits (20%);**
- **Technology transfer benefits (20%);**
- **Experience and qualifications of the proposing organization(s) (20%); and**
- **Level of commitment and organization structure (20%).**

The second RFP will not solicit specific technologies but will give some examples of appropriate generic technologies.

12. **What is the relationship between the priorities in the Critical Technologies list which your office will submit to the Congress and the priorities in the Advanced Technology Program?**

We regard the Critical Technologies list as an excellent summary of the current opportunities for the U.S. and expect this list to be very helpful in implementing the Advanced Technology Program selection criteria. However, distribution of funds for actual awards should be merit based and decisions made in accordance with how well specific proposals meet the selection criteria.

13. **Would you recommend that the Advanced Technology Program money be earmarked by Congress for particular technologies?**

No, we believe that industry should submit proposals based on its judgments of promising research and commercialization opportunities, and NIST should fund those proposals with the highest technical merit.

14. **Legislation passed last year authorized a Critical Technologies Institute organized as a federally funded, contractor-operated organization attached to OSTP. What is the current status of this Institute? How do you see the Institute being used by OSTP? Will it help OSTP, which has been chronically understaffed in the past, more effectively carry out its many responsibilities?**

The National Critical Technologies Institute was established by the 1991 Defense Authorization Act. The law requires the Institute to:

- **Survey the views of industry; academia; and Federal, State, and local government on the critical technologies identified by the National Critical Technologies Panel and other technologies they consider critical.**
- **Identify near-, mid-, and long term objectives for research, development, and production capability for each technology.**
- **Prepare possible strategies to achieve the objectives.**
- **Publish reports describing the national objectives and strategies and the progress in meeting them.**
- **Perform additional duties as assigned by OSTP and the Federal Coordinating Council for Science, Engineering, and Technology (FCCSET).**

It is our intent that the National Critical Technologies Institute will be operational by June 1991. Administrative support for the Institute is being sought through contractual arrangements with an existing not-for-profit organization that is capable, additionally, of providing technical support. Now that the report of the National Critical Technologies Panel has been completed and submitted to the President, it is expected that the pace of implementation of the Institute will increase. The findings from the study funded with FY 1990 appropriations should be useful to OSTP in carrying out its responsibilities. We anticipate that the Institute Director, who will play a key role in its establishment and ultimate structure will be appointed in the near future.

15. What do you believe should be our priorities for funding research in the areas of energy alternatives to fossil fuels and more efficient energy technologies? Do you believe the President's budget request is adequate to meet our current energy R&D needs?

The National Energy Strategy (NES) identifies a number of important technology opportunities in the areas of alternatives to fossil fuels and energy efficiency. For example, battery development has the potential to enable competitive electric vehicles to displace imported oil. Solar, wind, and other renewable energy will serve important niches. The efficiency of energy technologies can be significantly increased through materials science research and development in areas such as superconductors, high temperature ceramics, improved insulating materials, CFC replacements, etc. Nuclear fission merits vigorous development as the only technology available in the near term capable of producing large blocks of electrical energy without direct emissions of carbon dioxide, sulfur oxide, and nitrogen oxide. In particular, I believe that the new High Temperature Gas Cooled Reactor holds especially high promise among the next-generation reactors now under development. The President's budget requests adequate funding to meet our needs and proposes to leverage that investment through cooperative, cost-shared efforts with industry.

16. This Committee expects to address the issue of uranium enrichment this year. What is the Administration's policy on the importation of Soviet SWUs? Will there be unlimited importation or will some type of restraint agreement be worked out using the Department of Energy as the broker?

There are no restrictions on the importation of SWUs from other countries. To our knowledge, there are no plans to implement import restrictions.

17. Despite the EPA Science Advisory Board's 1988 recommendation that the EPA R&D budget be doubled over the next 5 years, the FY'92 budget is the first request for a significant increase (14%) in funding. Is the Administration committed to requesting similar or greater increases over the next few years so that we might approach the SAB's recommended levels?

The budget places a major emphasis on efforts to protect and enhance America's natural resources and the environment within the context of policies to promote economic growth. Major increases are proposed in the FY 92 budget for a number of important areas, including R&D. Although it is difficult to predict future budget recommendations, if the programs demonstrate sufficient merit, the Administration will carefully consider requests for funding increases.

18. **In the Superfund Amendments and Reauthorization Act of 1986, the Congress establishes at the National Institute of Environmental Health Sciences (NIEHS) a university-based multidisciplinary research program to develop better methods for assessing the risks to human health and for reducing those risks. With an FY 1991 appropriation of $21.9 million, the NIEHS is funding 11 grants involving 99 separate projects at 21 institutions. Although the President's Request includes a substantial increase for the Superfund budget, the NIEHS Superfund Research Program was cut by 46% to $11.9 million while the 1990 reauthorization provided $35 million for FY 1992-1994. What is the reason for the drastic cut in this excellent program?**

The NIEHS Superfund Basic Research Program is designed to answer the questions most often heard from people whose environment has been affected by uncontrolled hazardous substances: "What are the risks to me and my family and what can science and technology do to help us?" The NIEHS Program provides multiproject, multidisciplinary grants to universities to fund integrated studies in biomedicine, engineering, hydrogeology, ecology and statistical modeling. The knowledge gained will provide a sound foundation for decisions about managing hazardous substances in ways that protect human health and the environment.

The NIEHS Superfund Basic Research Program receives its funding from the Superfund Trust Fund through the Environmental Protection Agency. This research is important for the future of the Superfund Program; the techniques and methods developed by NIEHS-sponsored researchers will make the Superfund more cost-effective and will enable EPA to set priorities so that cleanup activities can produce a healthier environment. The FY 1992 total EPA Superfund budget proposes an increase of $135 million over its FY 1991 appropriation. However, the urgency of cleaning up sites of concern to the public dictates that funding for research be a lower priority than that for immediate cleanup and enforcement efforts.

19. **In its review of the FY 1991 United States Global Climate Research Program, the National Academy of Sciences commented on the need to achieve an appropriate balance between space-based observational capabilities and ground-based process studies and modeling research as the program evolves. How does the FY 1992 budget respond to this recommendation?**

Overall constraints on Federal funding have led the Committee on Earth and Environmental Sciences to pursue a U.S. Global Change Research Program (USGCRP) more focused on the highest priority scientific and policy issues over the next few years. In particular, the highest priority scientific and policy issue for the USGCRP in FY 1992 is whether, and to what extent, human activities are changing or will change the global climate system.

The FY 1992 budget proposed by the President for the Program is consistent with the Academy's recommendation. The budget reflects a continued commitment to establish an integrated, comprehensive (space- and ground-based) atmosphere, ocean, and terrestrial observing system which will acquire the long-term databases necessary for the development and testing of predictive models and for monitoring to document global environmental changes. The budget also reflects a strong, continued commitment to conduct focused studies necessary to improve our understanding of key processes that control the global Earth system, including its climate. Further, a strong commitment is reflected in the budget to augment research on climate modeling and prediction, one of the highest scientific priorities identified by the Intergovernmental Panel on Climate Change.

The proposed funding level for spaced-based research programs in the USGCRP in FY 1992 is $596.2 million; an increase of 23.2 percent over the FY 1991 level. A comparable increase is requested for ground-based research. The funding level requested for these activities is essential if we are to put in place space- and ground-based systems necessary for observing key environmental processes at the global scale, a scientific capability that we presently lack. We agree with the Academy's recommendation of maintaining an appropriate balance between space- and ground-based research and observation programs. Such a balance is essential for a successful USGCRP given the spatial and temporal variability of the systems being studied and the need to scale processes occurring at the local level to the regional and global scales.

The remainder ($589 million) of the proposed budget of $1186 million for the USGCRP in FY 1992 is for a combination of ground-based studies, modeling, and data management. The level of funding for these activities is, in the view of the CEES agencies, consistent with the scientific needs and priorities, the state of science, and the development of the USGCRP.

20. Last year you expressed considerable pride in the model that the Committee on Earth and Environmental Sciences and the USGCRP provided for interagency program development and integration, and your intentions to apply that model to other science and technology arenas. Could you give us an update on your efforts?

Upon confirmation, one of my early goals was to reinvigorate interagency collaboration in key fields of science and technology relevant to the missions of several agencies. As you are aware, the Federal Coordinating Council is an interagency forum within the Executive Branch for reviewing and coordinating research and development activities that cut across the missions of several federal agencies. Reflecting strong support throughout the Administration, the Council is now comprised of Cabinet secretaries, deputy secretaries, and heads of independent agencies that have statutory authority for R&D programs in the federal government. These departments/agencies integrate and help to implement federal science and technology policy. The Council has seven umbrella subject-matter committees whose members are Assistant Secretary or equivalent level representives of their respective agencies or departments. Unlike the committees in the Legislative Branch, each of which has discrete authority for oversight, FCCSET committees are mechanisms for discussion, analysis, collaboration, and consensus building. The member agencies bear the responsibility for implementing the programs developed through the interagency process, as proposed by the President and as legislated by the Congress.

I am pleased by the accomplishments of the FCCSET. This year the work of the Council resulted in the first comprehensive inventory of the ongoing federal efforts in mathematics and science education, and in the identification of opportunities to maximize federal activities in support of the education goals established by the President and State Governors. This effort, and a parallel one involving high performance computing, helped to bring forward two new Presidential initiatives in the R&D budget for FY 92 -- the U. S. Mathematics and Science Education Program and the U. S. High Performance Computing and Communications Program. In addition, the Council coordinated the continuation of a third Presidential initiative, the U. S. Global Change Research Program.

Calibration and validation of FCCSET activities by the private sector is of great importance, in my opinion, but by law all members of FCCSET and of FCCSET committees are government employees. I am pleased that the President's Council of Advisors on Science and Technology (PCAST), which reports directly to the President, fills this gap so effectively and provides this essential private sector input to our deliberations.

21. **The Budget proposes a 71 percent increase ($52 million) for Agricultural Research, most of which is for the competitive grants program. In the longer term, how do you see the balance in the Agricultural Research program between the competitive grants program and the older, decentralized formula program under which block funding is provided to the agricultural land grant colleges in each state?**

The Administration fully supports the goals of formula block grant programs for maintaining States' basic agricultural research programs. The competitive grants program in the National Research Initiative is designed to foster cutting-edge research to complement that done with formula block grant funds. Provided that the program is as successful in stimulating cutting-edge research as we think it will be, we will seriously consider requesting additional funding for the NRI.

22. The President's budget calls for making permanent the research and development tax credit as a means of spurring long-term R&D. Please elaborate on what you see as the potential benefits of such a tax policy. What are the potential tax expenditures?

The Administration is extremely concerned that the rate of growth in industrial R&D has leveled off since the mid-1980s. For 1990 and 1991, both the National Science Foundation and the Battelle Memorial Institute estimate that industrial R&D will, at best, keep pace with inflation. The tax incentive can help boost private R&D investment. The fact that the credit has not been a permanent one has kept it from having a maximum impact on long-range corporate planning. Making the credit permanent will permit businesses to establish and expand R&D operations and facilities without fearing that the tax laws will suddenly change. The revenue cost of a permanent research and experimentation tax credit is estimated to be $6.2 billion from fiscal years 1991 through 1996.

23. Does the Administration plan to submit a proposal to Congress addressing the competitive disincentives of current anti-trust law?

The Administration has proposed legislation to eliminate concern that our antitrust laws may be applied unreasonably to joint ventures that produce goods and services, including joint ventures between competitors, and thereby benefit U.S. international competitiveness and consumers alike. On May 7, 1990, Attorney General Thornburgh and Secretary Mosbacher transmitted to Congress the Administration's proposed "Cooperative Production Act of 1990." This bill would amend the National Cooperative Research Act of 1984 to extend its coverage of research and development joint ventures to production joint ventures as well. The NCRA clarifies that the potentially precompetitive joint ventures it covers are to be analyzed under the antitrust "rule of reason" that takes full account of international competition as well as potential efficiencies. NCRA coverage also provides for reduced antitrust damage exposure upon notification to the antitrust agencies.

24. Please submit to the Committee the memorandum to EPA listing your nominees for witnesses at the Science Advisory Board hearings on the EMF report. Who (by name and organizational affiliation) provided you with the names of your recommended witnesses?

We are not at liberty to disclose the confidential deliberative processes within the Executive Branch, but the Committee can be confident that all responsible points of view were considered in our reflections on this important issue.

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